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SURGERY

ITS PRINCIPLES AND PRACTICE

BY VARIOUS AUTHORS

EDITED BY

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SURGERY

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CHAPTER XXXVI.

SURGERY OF THE HEAD.

By Harvey Cushing, M.D.,

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PART I.

The External Coverings of the Skull.

"This, though it be called the common tegument of the head, yet injuries done to it become of much more consequence than the same kind of ills inflicted on the common teguments of the rest of the body."—Percival Pott.

Anatomic Considerations.—The scalp is subject to the same diseases which affect the external coverings of the body elsewhere, but owing to its structural peculiarities local injuries, infections, or tumor formations have characteristic features which are out of the ordinary. In the extremes of life the protective covering of the cranium is inconsiderable, in early childhood forming a delicate and loosely attached layer, in old age, or with the falling out of the hair, again becoming a thin, though much less freely movable layer. The heavily haired scalp of the intervening age, on the other hand, forms a dense, elastic mat of greater thickness than one who has not made a study of frozen sections of the head would suppose. The subcutaneous layer is composed of bands of dense fibrous tissue, enclosing lobules of fat, giving to it a degree of firmness and elasticity comparable to that possessed by the tissues under the palm and sole; this adipose layer is but little affected in general obesity or in emaciation.

A dense, fibrous membrane—the *galea aponeurotica*—to which the occipitofrontalis muscle is attached, forms the lowest layer of the scalp proper, and it moves more or less freely on a bed of loose cellular tissue which separates it from the outer periosteal covering—the pericranium. In this loose *subaponeurotic layer* suppurative processes may burrow widely before finding an exit to the surface; it is there also that flaps are usually made by wounds, during operations, or in the usual method

of post-mortem examination; it is in this layer that total avulsions may occur, owing to a violent wrench upon the hair, whose strength may be great enough even to suspend the body, Absalom-like, without itself giving way.

The *pericranium*, or external periosteum, is particularly adherent to the bones at the lines of suture; hence effusions under it of blood or fluid are often limited in extent to the surface of one bone. It retains, even in adult life, some slight power of making new bone, and when elevated by effusions or when left as a fringe about a cranial defect a ridge of new-formed bone-tissue appears. This property may serve as an aid in the diagnosis of certain swellings, as cephalhematoma and pneumatocele.

No matter what the external preparation may be, the scalp cannot be rendered amicrobic, owing to the depth of the hair follicles and glands; hence every incision will sow bacteria over the raw surface. The usual flora, however, possesses no active pathogenicity, and it is consequently a mistake to employ too vigorous and repeated efforts to sterilize the surface before operating. Though the scalp is smoothly stretched over the calvarium, being furrowed by the action of the frontalis over the forehead only, it may, however, in some instances be thrown into rigid longitudinal folds, so that close shaving in the depth of the creases is practically impossible.

Though there is a local absence of glands, the *lymphatics* are abundant and empty into glands remotely situated: from the back of the head into the deep suboccipital glands; from the posterior parietal region into the mastoid glands; from the anterior into the parotid glands; while those from the brow may pass back to the parotid region or across the face to the submaxillary lymphatics.

Its chief *blood supply* comes from the occipital, temporal, and supra-orbital vessels; hence an elastic tourniquet placed about the occipito-frontal circumference serves to block the arterial circulation. In the making of flaps it is desirable to allow one of these vessels to enter the pedicles; the capillary vascularity, however, is so great that a large flap may retain its vitality even when this precaution has not been taken. Owing to the density of the tissue the vessels do not readily constrict after division and, consequently, scalp wounds may lead to profuse hemorrhage. It is often difficult, particularly in old people with sclerotic vessels, to isolate and ligate them, and it may be necessary to pass ligatures with a needle so as to include surrounding tissues as well. Hemorrhage can usually be checked and ligation avoided by accurate suturing of the wound's edges and subsequent pressure.

Much of the venous blood finds its way to the jugular by way of intracranial vessels and, as the venous channels within the skull quickly feel the effects of an increased intracranial pressure, the resultant stasis is transmitted to the veins of the scalp, where it becomes an early evidence of such a process. Thus, the visible distention of the veins of the brow—or of the entire scalp when shaved—may be a striking objective sign of an acute increase of intracranial tension. The same

thing occurs in association with chronic intracranial processes like hydrocephalus; and in tumors the stasis of the extracranial veins may be so great as to cause after incision a disturbing loss of blood, which is, of course, uncontrolled by a tourniquet. I regard the dilatation of the venules of the upper eyelid as a fair index of the degree of stasis, which the ophthalmoscope will demonstrate in the retinal vessels.

The return of venous blood from the scalp by an intracranial route is of great moment in all external infected wounds, owing to the possible extension of phlebitis to the venous sinuses.

The *nerves* are almost entirely sensory, and after traumatic or operative division and during the process of regeneration discomforts such as Henry Head has described may occur from "protopathic" disturbances. These are more persistent when nerves have been caught in scars; hence it is of importance to accurately approximate all wounds, so as to insure early reunion of nerve-fibers. One motor branch—namely, the upper twig of the pes anserinus to the frontalis muscle—is of importance, since in many of the common operations in the temporal region it may be injured and lead to deformity from unilateral paralysis of the brow.

Wounds and Contusions.—Scalp wounds are usualy classified as contused, incised, punctured, or lacerated.

Contused wounds lead to extravasations of blood which collect between the layers of the scalp itself or under the galea or pericranium. The subcutaneous hematomas are usually small, hard, circumscribed swellings which can be moved with the scalp. They are more apt to be caused by direct blows; whereas glancing blows which cause the scalp to slip away from its subaponeurotic attachments, or the pericranium from the bone, lead to effusions in these lower layers. A subaponeurotic hematoma may give a wide area of fluctuation, surrounded by a more elevated, denser rim, where the effusion has thickened the tissues by infiltration. This hard, raised edge of a hematoma is often misleading, for it may closely simulate a depressed fracture. Effusions under the pericranium are common in infants, for with advancing years this membrane loses in large part its abundant vascular attachments to the skull. Cephalhematoma will be considered in a later section. These collections of blood, whether under galea or pericranium, usually resorb, so that an expectant treatment is the usual one. If they are large, however, the evacuation of the fluid contents by aspiration or open incision will hurry the process of healing. They sometimes become infected and free incision is then demanded. Owing to the unyielding character of the underlying bone, blows upon the head, even from a blunt weapon or the result of a fall upon a smooth surface, may produce a wound which looks as though it had been incised. The edges of such a wound, however, are always contused, and swelling and ecchymosis rapidly appear. Hemorrhage may be profuse and a small wound may give the appearance of a serious injury. Hence it is a common experience, when the clotted blood has been washed out of the hair and the scalp shaved about such a wound, to find it—aside from the bleeding—a trifling affair. When a wound is superficial and does not penetrate

the aponeurotic layer its edges do not gape, but in case the galea has been divided, its edges separate considerably, owing to the pull of the muscle fibers. This is more marked in transverse wounds than in those having a sagittal position. It is to be remembered too that the galea may be split by a wound which has merely contused, but not opened, the outer layers of the scalp. Palpation of such an injury often leads the unsuspecting to make a certain diagnosis of cranial fracture—a common enough error even for the experienced. When the matter is doubtful an unnecessary exploration is far better than an overlooked and neglected depression.

Simple incised wounds, whether associated with contusion or not, heal kindly. With scrupulous cleansing and disinfection and careful

FIG. 1.—CASE OF TOTAL AVULSION OF SCALP.
Showing V-shaped prolongation at root of neck; area granulating; considerable progress in skin grafting above right ear. (Geo. W. Spencer's case, Jefferson Hospital Medical College.)

parting of the hair they may be closed with interrupted sutures without even shaving the neighboring scalp, though this precaution should usually be taken. In any case they must be attentively watched for the first few days and the sutures, especially if they have penetrated the galea, should be removed as early as the second day.

Punctured wounds are less common. A well-directed blow with a pointed weapon may penetrate the skull as well as the scalp, but these blows are usually glancing and are more likely to slice off a flap of scalp. They sometimes produce a deep track, which may need opening lest infectious material, carried in by the instrument, set up a subaponeurotic

suppuration. A blade glancing into the temporal region may be broken off behind the zygoma. Serious hemorrhage may follow deep wounds of this character and carotid ligation may be necessary.

Scalp wounds are commonly associated with more or less *laceration.* All grades of injury may occur, from a simple point of tissue reflected by a sharp implement, to the tearing away of a large portion of the external covering from the glancing blow of a rough object which catches and rips up a ragged flap. The resultant flaps may be of any shape or size and their edges irregular, contused, and shredded; hemorrhage may be considerable; as they are often the result of falls, dirt may be ground into them; they are often accompanied by cranial fractures and, in turn, by cerebral symptoms; they are, in short, almost always complicated injuries.

There is one notable exception to this rule in the case of *avulsion.* This distressing accident occurs more commonly in women who work in factories and whose long hair, having become entangled in revolving machinery, is wrenched from the head, dragging away the scalp down to the pericranium. The avulsion may be a total one, with loss of the external coverings, from the supra-orbital ridges back to the occiput. The denuded area is apt to show a peculiar form, running down to a point in the midline of the root of the neck (Fig. 1). Similar lesions have been recorded among men—the keepers of wild animals—their heads having been denuded by a single sweep from the paw of an infuriated beast whose unsheathed claws have fastened in the scalp. In comparison with lacerations from other causes these flaps may be comparatively clean, and when incompletely torn away they may be replaced—if their blood supply is sufficient—with the prospect of at least partial reattachment. In some cases the entire scalp may be saved (Fig. 2). Usually there will be a resulting area of denudation which granulates and which should be spread with Thiersch grafts as early as possible, in order to lessen the scar-formation, which otherwise leads to an unsightly deformity through the pulling up of the loose tissue about the orbits. The prognosis of these injuries is less bad than might be supposed, though without grafting it may be years before the wound becomes completely covered with epithelium. In this case there may

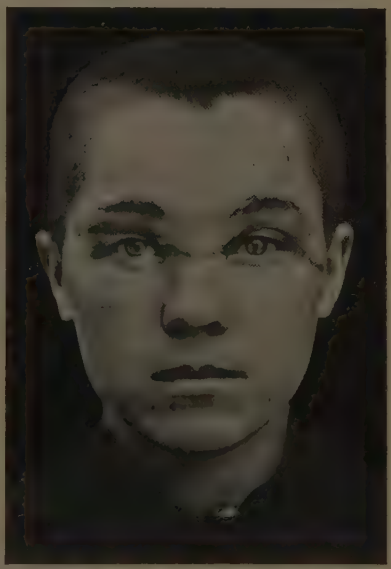

FIG. 2.—CASE OF PARTIAL AVULSION, WITH SUFFICIENTLY VASCULAR PEDICLE TO ALLOW OF SUCCESSFUL REPLACEMENT OF SCALP.

Note lines of cicatrix at root of nose and angles of palpebral clefts. (C. A. Porter's case, Massachusetts General Hospital.)

result a thin, tender cicatrix, whose blood supply is so poor that there may be recurring ulcerations in which epithelioma may ultimately appear.

Treatment.—The immediate treatment of lacerated wounds of the scalp, when thoroughly carried out, is a painful procedure and usually calls for general anesthesia, even when there is no cranial complication. The scalp and the loose flaps must be shaved, the open wound meanwhile being protected so far as possible with a sterile gauze pack. Sand, oil, cinders, dust, and other dirty material from the surroundings where these injuries are likely to occur must often be literally scrubbed from the tissues with a stiff nail-brush under an abundant irrigation of a sterile or slightly antiseptic solution. Fresh incision may be needed in order to clean the under surface of the flaps and to remove pockets of clotted blood, which, if retained, are likely to encourage suppuration. The ragged edges of the wound should be trimmed away, especially when they are ground full of dirt. The extent to which these wounds may be safely closed depends entirely upon their character and the likelihood of subsequent infection. In any case they should merely be loosely approximated with interrupted sutures, and drainage by counter-openings is often advisable. Experience alone enables a surgeon to determine when such a wound may safely be closed in its entirety—and experience is fallacious. A seemingly insignificant wound may suppurate; an extensively lacerated and dirty one may heal with the minimum of reaction. The moral is: Let no lacerated wound of the scalp, however trifling, escape from observation for more than a few hours at a time—a day at the outside, as they are often ambulatory cases—for early attention may save the patient from the serious consequences of neglect, to be described.

Infections.—**Diffuse cellulitis**, or phlegmon of the subaponeurotic layer, is one of the commonest sequels of misdirected treatment. The vascular edges of a closed wound may promise for some days to unite without reaction, and thus the more deep-seated trouble which is brewing may be concealed. Some tenderness and bogginess of the tissues, however, will appear, associated with fever and a quickening of the pulse, and unless the sutures—often left in too long even in properly healing scalp wounds—are promptly removed and the edges of the incision opened to give vent to the inflammatory discharges, serious results may follow. Infection, confined in the loose subaponeurotic space, finding no natural means of exit, may spread in extreme cases over the entire calvarium. In such cases counteropenings around the dependant parts of the scalp must be made for drainage, but since tension—the factor above all others to encourage the spread of cellular inflammation—can thus be relieved only in a measure, the process may continue and lead to still more serious complications. The pericranium, even if not partially torn away from the skull by the original injury, finally becomes involved in the process and the exposed bone lies bare to the infection, which often attacks it greedily. The resulting osteomyelitis may, in fortunate cases, include only the outer cranial table,

or it may invade the diploë and inner table and sequestrate large areas of the skull-cap. Even in less extensive processes infections may travel through the diploëtic vessels to the intracranial sinuses or infect the cerebrospinal fluid.

The purulent secretions from these infected wounds are abundant, often foul smelling, and difficult to take up into dressings, tending rather to trickle down alongside the face, where they become encrusted. Frequent cleansing irrigations with the application of abundant loose dressings are necessary. During the active period of such a cellular inflammation the flaps of the original wound must needs have been widely thrown open and their retraction may leave a large defect by the time the phlegmonous process has become quiescent. In such cases the tedious process of repair by granulation and epidermization—the latter often successfully aided by grafting—must be awaited.

Fig. 3.—Subperiosteal Abscess of Temporal Region Secondary to Mastoid Disease.

Showing characteristic swelling and displacement of pinna. (The Johns Hopkins Hospital.)

Subpericranial Abscesses.—These collections of pus are usually limited in extent to the surface of a single cranial bone, owing to the pericranial attachments which have been described. They are often due to the secondary infection of a cephalhematoma, whether from operative or hematogenous sources. I have seen a case infected with the gonococcus accompanying ophthalmia. These abscesses often are secondary to osteomyelitis, the most familiar type following otitic or mastoid disease, in which case the pus often finds its way into the temporal region, causing a characteristic swelling with displacement of the ear (Fig. 3).

Erysipelas, in pre-Listerian days, was a frequent sequel even of insignificant scalp wounds, and inasmuch as streptococci may be denizens of the scalp, it need not be a matter for surprise. At present, however, the edges of simple incised wounds, like operative ones, though they must be strewn with cocci of various kinds, rarely become infected. In a series of over 300 cranial operations through an intact scalp I have never seen a subsequent infection of the skin with any organism whatever. Even a so-called "stitch abscess" (staphylococcal) will never occur, provided the sutures are removed sufficiently early. Streptococcal scalp infections more commonly originate in minute wounds of

the nose or ears. When the process reaches the scalp it does not manifest itself as elsewhere upon the body; for, owing to the density of the subcutaneous tissues, possibly also to an unusual arrangement of the lymphatics, the usual sharp demarcation, redness, and elevation of the skin are largely absent. Hence erysipelas originating in the hairy scalp may be unrecognized until its red skirmish line comes "into the open" on the forehead. It has often been noted that deep-seated infections containing streptococci may be unattended with any erysipelatous blush on the surface, but that when such processes are incised the superficial lymphatics are infected and the characteristic subcutaneous lesion may be established. It is wise, therefore, to make incisions into such deep-seated abscesses with the actual cautery, the blade of which immediately seals the divided lymphatics.

Symptoms.—During the active spread of the infection, due in great part to the toxins, there is fever with other constitutional symptoms—among them delirium—so that meningeal complications may be feared. The latter are, however, rare, unless there has been a fracture with deep-seated infection as a complication of the original injury, in which the erysipelas also got its start. Healthy adults rarely die from uncomplicated erysipelas, even in its migrating forms, when it may extend over the whole body. It is serious only in debilitated people, who, as a matter of fact, show a special disposition to the malady.

Treatment.—Erysipelas is usually a self-limited disease—seven to nine days is said to be its average duration on the scalp—and hence the treatment is largely a constitutional one. Cooling, slightly antiseptic lotions, or even cold water, give local comfort, and probably the more radical measures—as incisions about the spreading margin or the subcutaneous injection of antiseptics in advance of the process—are unavailing, if not injurious. The use of antistreptococcus serum is of very questionable advantage. Bier's treatment, with a band about neck or head, may be helpful.

A **local phlegmon** (the staphylococcal **furuncle** or **carbuncle**) is of frequent occurrence, especially on the occipital portion of the scalp. Carbuncles, however, more often originate on the neck below the hair margin and invade the latter by extension. They may extend deeply and when their central slough is removed the bared bone may be exposed. Their proper treatment is by complete and early extirpation, as has been described in another chapter. Suction or stasis hyperemia may be used.

Spreading and usually fatal *gangrene* of the scalp occurs sometimes in badly nourished children. It is supposedly due to some particular organism. Patches of dry gangrene on the back or sides of the head may be seen as actual "bed-sores" in marasmic children. They are particularly common as a consequence of pressure on a hard pillow from the great weight of a hydrocephalic head. These children often cannot change their position unaided, and the thin scalp, deprived of its circulation for any length of time, loses its vitality. Pressure even on the more resistant scalp of an adult—as from too tight and prolonged

application of a tourniquet or bandage—may produce a band of superficial gangrene.

Chronic ulcerations may occur when the contracting cicatrix of a large wound prevents total epidermization; from the breaking down of new growths; or from tuberculous or syphilitic processes. The latter are commonly of cranial origin and will be considered in a following section.

Affections of the Blood-vessels.—Simple Aneurysm.—From their exposed position, encased in inelastic tissues which overlie an unyielding surface, the extracranial vessels are prone to injury. Although the arteries may undergo, with advancing years, an extreme degree of atheromatous change, spontaneous aneurysms are rare. They usually are of traumatic origin and have a false sac, formed by a local extravasation of blood, rather than through a true distention of the injured vessel wall. They are usually small and, as a rule, occur in the temporal region. They are easily recognized and may be readily and safely extirpated. A large number of these cases have been collected by De Sauti.

Arteriovenous Aneurysm.—In the production of this lesion traumatism again plays the important rôle, and an injury from a sharp-pointed instrument or missile is usually the inciting cause: a stab or bullet wound; a fall upon a sharp stone; and, in former days, accidents from venesection practised in the temporal region. A mere blow upon the vessels by a blunt object may lead to necrosis of the adjoining walls and subsequent perforation and communication. Here again the temporal region is the usual site for the lesion, although it may occur elsewhere. I have reported a case in which the anastomosis lay between the occipital vessels at the level of the superior curved line (Fig. 4).

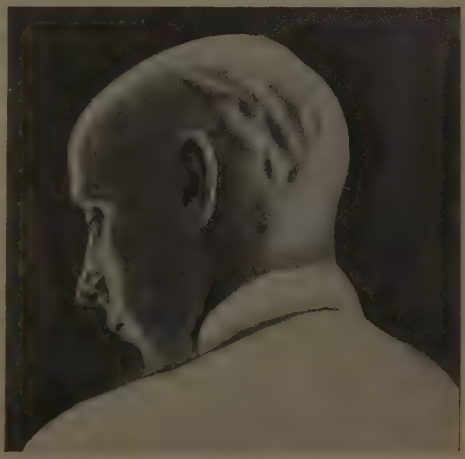

FIG. 4.—ARTERIOVENOUS ANEURYSM OF THE OCCIPITAL VESSELS.

As elsewhere in the body, such a lesion leads to a reversal of the circulation in the venous tributaries peripheral to the point of communication. The vessels become increasingly larger and, when not well supported by the surrounding tissue, may balloon to a considerable extent, despite the tendency of their walls to become hypertrophied (arteriolized) in consequence of the increased work put upon them. Ultimately a large part of the scalp may become covered by these enormously dilated and pulsating veins, which lie in palpable grooves, due to atrophy of the subjacent tissues. The tumor-like swellings

which result may give an unsightly appearance and the systolic hum and thrill from the passage of blood through the narrow anastomotic communication may be audible to the patient and cause great annoyance thereby. There is no particular menace to health and activity from an aneurysm of the scalp, but it is subjectively annoying, unsightly, and surgical aid is sought in consequence.

The *treatment* is more simple than is the case with arteriovenous aneurysms elsewhere, since total extirpation of both the artery and vein, together with their pathological juncture, is possible without risk other than the immediate hazard of hemorrhage during the operation. The chief operative difficulty lies in the fact that the large dilated veins—whose content is under abnormally high pressure—are, in consequence of their position in the dense scalp, almost impossible to isolate. It is well for the surgeon, in attacking these cases, to make a crescentic incision around the point of anastomosis and to turn back a flap of scalp down to the aponeurotic layer, above which the vessels lie. They can then be more easily dissected away from the under surface of the everted flap. The older methods of treatment by galvanopuncture or injections are unsurgical and rarely effect a cure. Compression and the Hunterian operation for aneurysm are likewise rarely successful.

The most common of all the arteriovenous aneurysms of the head results from a communication, usually traumatic, between the internal carotid artery and cavernous sinus. It will be considered in a subsequent section (p. 132).

Angioma.—Though on nosological grounds there may be objections to the inclusion here of certain affections of the blood-vessels commonly designated as tumors, it is convenient to take them up at this time, and to place them under separate headings, according as they affect primarily the arteries, the terminal capillaries, and venules, or, lastly, form true neoplasms composed of large vascular spaces.

Cirsoid Aneurysm.—This curious and rare affection is not, in a true sense, an aneurysm, though among English writers it is best known under the above term. It was classified by Virchow among the tumors of blood-vessels and called "*Rankenangiom*," or *angioma arteriale racemosum*. The uncertainties regarding its morbid anatomy and etiology, and the probability that under the term have been included lesions which primarily originated either as "aneurysms by anastomosis" or from the transformation of a true cavernous hemangioma, make of it a malady which greatly needs further elucidation.

The process shows itself as a subcutaneous swelling, made up of a pulsating meshwork of arterial sinuses, from which radiate pulsating vessels that can be distinguished as individual trunks; whether originally containing arterial or venous blood is not always clear. Thus, it is not a new growth, in the commonly accepted sense of the term, but rather a morphological change in the pre-existing structures. The disease is supposed to start as a widening and dilatation of the branches constituting a particular arterial tree, and affects with greatest frequency the vessels of the face or scalp. The next most common site

is the forearm and hand. This widening and lengthening of the arteries, with thickening of their walls, extends ultimately even to their finest twigs and capillaries, and the vessels of a lower order are supposed to become transformed into those of a higher one. Traumatism has been known to play a part in inciting this transformation of the vessels, as, for example, the constant pulling on the lobe of the ear in a case of König's, but usually no assignable cause can be given. Lexer is of the opinion that some developmental fault which affects the particular vascular territory concerned lies at the bottom of the process.

The vermiform tangle of dilated vessels may become covered by a thinned, reddish, and adherent skin, in which telangiectatic stains appear. A systolic blow and thrill may be transmitted to the palpating hand and a systolic murmur may be present, but it is less characteristic, and pressure on no one point obliterates the bruit, as in true arteriovenous aneurysm.

The progress of growth may at first be rapid and later slow—broken by pauses in its extension. The complications are manifold. There is a distressing thrill and pulsation; fainting attacks may occur; there may be pain from inflammatory involvement of adjoining nerves; ulceration of the overlying skin may occur with fatal hemorrhage or resultant infection.

Treatment.—No form of treatment has met with uniform success. Central ligation of the main arterial trunk has proven unavailing or has only given temporary relief; in the extremities it has led to gangrene. Efforts to produce thrombosis and solidification of the vessels by injection of alcohol or other fluids is not without danger, as the tissue between the vessels is small in amount and there is danger of injection into the vessels. Complete extirpation with ligation of all the radiating trunks is the ideal method, but one which is unfortunately often impossible of putting into effect. When the disease has advanced it is often beyond any known remedial measure.

Vascular Nevi (*Hemangioma Simplex*).—These vascular stains—the "port-wine" marks of the vernacular—occur as congenital blemishes, with especial frequence upon the face, forehead, and even on the hairy portion of the scalp. They are common as small insignificant patches—telangiectatic stains—but may, on the other hand, cover large areas of the head, face, or body. As capillary nevi, consisting of an abnormal dilatation of the small subcutaneous vessels, they may deform the outline of the cutaneous surface in no respect and show themselves only as a discolored patch, varying in tint from an arterial to a venous shade of red. When, however, veins as well as capillaries are implicated in the process, the surface may be deformed to a greater or less extent and the lesion, made up of prominent, dark, plum-colored nodules, may become very disfiguring. Attention has been called by Bärensprung, Etienne, and others to the fact that these vascular nevi are apt to possess a characteristic topographical configuration which corresponds with the outline of the skin fields innervated by one or another of the three main divisions of the trigeminal nerve (Fig. 5).

The suggestion is natural, therefore, that these superficial lesions are an expression of some prenatal affection of the sensory nerves and possibly of their dorsal root ganglia (the Gasserian in this case). With herpes zoster they might properly, therefore, be included under diseases of the cranial nerves. The relatively frequent occurrence of spastic hemiplegia in children possessing trigeminal nevi has led to the suggestion that the cerebral membranes may at times be involved in the abnormal vascularization leading to intracranial extravasations.

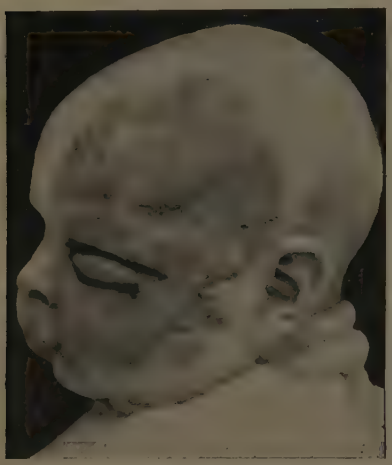

FIG. 5.—CONGENITAL NEVUS OF THE CAVERNOUS TYPE:

Involving completely the maxillary and partly the ophthalmic skin field of the left trigeminal nerve. (Case from the Massachusetts General Hospital.)

Simple vascular nevi may become transformed into growths taking on the properties of a cavernous angioma, and some regard them as the presumable starting-point for cirsoid aneurysms.

Cavernous angioma (*hemangioma cavernosum*) may be regarded as a true vascular neoplasm whose structure consists of irregular blood spaces resembling those normally found in the corpora cavernosa. As a rule, these tumor masses shade off without definite boundaries into the neighboring, normally vascularized tissues, but they may, on the other hand, become more or less definitely circumscribed: and thus, after a period of growth the circulation through them may become slowed; thromboses occur, and the growth may actually diminish in size through cicatrization of the blood spaces. Like the vascular capillary nevi these angiomata are usually congenital and often multiple, especially when distributed on the extremities. They occur, too, with greatest frequency upon the face and head, and especially when stimulated into active growth by injuries they may reach large proportions, justifying the term *elephantiasis cavernosa*.

The soft, elastic, honeycombed meshwork of tissue; the thin, overlying skin, which in patches allows the dusky blue color of the tumor to show through; the ability to partially empty the tumor and its immediate refilling; its congenital origin—all these leave no uncertainty as to the diagnosis.

The tumors occur with frequency about the orbit and may lead to a protrusion and jeopardize the safety of the globe. They are found arising from the glabella; they may appear on the top of the head. When in the latter situation, owing to the property which they sometimes possess of invading the neighboring tissues, they may lead to serious circulatory complications. One such case has come under my observation: a middle-aged woman, who for years had noticed the

presence of a small cavernous angioma on the crown of her head near the mid-line. Following an injury this grew rapidly to the size of one's fist, led to the absorption of the underlying bone, communicated presumably with the longitudinal sinus, and finally assumed the characteristics of a cirsoid aneurysm. It became pulsating, acquired a loud and distressing systolic thrill, and large pulsating vessels radiated from it, like a caput medusæ, over the scalp and face. An intercurrent trouble led to her death, and the tumor, which had not invaded the dura, was found to be a simple cavernous angioma. Lannelongue has collected 12 cases of this sort.

The *treatment* of the simpler forms of nevi does not usually lead to a great improvement in appearances, and as it is largely for cosmetic reasons that it is undertaken, most people prefer nature's mark to the cicatrix with which the surgeon may sometimes replace it. The capillary forms are apt to fade during the early months or years of life. When, however, they are associated with dilatation of the veins, are especially unsightly from their dark color, and project as irregular tufts from the skin, there may be more reason for operative intervention. The methods for the flat, widespread growths resolve themselves into the effort, at repeated sittings, to set up local areas of inflammation, which lead to scar formation and obliteration of the vascular spaces. For this purpose multiple punctures with the thermocautery, the external use of caustics —as nitric acid—or the subcutaneous injection of irritating fluids have been advocated. When of small extent they may be extirpated with the knife, the wound being left to cicatrize or covered with a Thiersch graft. The thick projecting masses of spongy tissue which constitute isolated tumors of the cavernous type are also suitable for excision, but when these growths are upon the scalp and have invaded the bone, surgical interference with the knife is attended by great risk of fatal hemorrhage.

Affections of the Nerves.—Hyperesthesia may occur as a form of "referred pain of visceral disease." It is most commonly seen in association with local inflammatory lesions of the dura matèr, and thus it may be of some aid in the diagnosis of other processes.

The Neuralgias.—Any sensory nerve may become the seat of neuralgic pain, but the suboccipital and supra-orbital nerves are most commonly involved, leading to the most persistent, painful, and intractable of maladies. At times some local process may be found to account for the trouble—as involvement of the nerve in a scar, its passage through a bony foramen, or the pressure of a tumor—and removal of the cause may prove curative. But only too often a process designated as an "ascending neuritis" has been set up, and not only does pain continue in the original territory, but it spreads to adjoining ones. Many of these neuralgias arise without any assignable cause, and although their etiological factor is unknown, their primary seat is supposed to lie in the posterior root ganglia (Gasserian or upper cervical). In the following type, however, the primary seat of the lesion is assured.

Post-zoster Neuralgia.—An outcrop of herpetic vesicles about the

nares and lips is a symptom of one of the commonest of ailments—"catching cold,"—as well as of the more serious febrile states. The mild vesiculation of herpes facialis is generally supposed to be something apart from the more extensive eruptions, designated as herpes zoster, the causal lesion of which is a hemorrhagic inflammation of the trigeminal or dorsal root ganglia (Head and Campbell). Howard has found small lesions, analogous to those described by Head and Campbell, in the Gasserian ganglion of patients who succumbed to such fevers as pneumonia at a time when there were herpetic outcrops about the nose and lips. Thus, it is conceivable that a degree of herpetic vesiculation, considered of no moment at the time, may incite further changes in the ganglia and become the precursor of neuralgia.

There is no doubt about this sequence when there has been an extensive zoster, and no one of the trigeminal zosters is so common as that involving the supra-orbital field—herpes zoster ophthalmicus. A severe attack of zoster in this area—particularly in old people and when the vesicles have been confluent and have ulcerated—leaves a scarred, tender, hyperesthetic field over the forehead and scalp, which is the almost certain forerunner of an intractable neuralgia. A simple peripheral neurectomy in such a case is unavailing and does not even temporarily interrupt the discomforts. If the malady is sufficiently incapacitating, an intracranial division of the sensory root or removal of the ganglion offers the only hope of permanent and complete cure.

Elephantiasis Nervorum.—This peculiar manifestation of von Recklinghausen's disease occurs, for some unaccountable reason, with especial frequency on the temporofrontal region of the scalp. It is usually accompanied by evidences of "multiple neurofibromatosis," but may occur as an isolated process in the absence of disturbances elsewhere in the body. As such it was first described by Valentine Mott under the term "pachydermatocele," and a number of other designations have been given to the lesion: "neuroma plexiforme," Verneuil; "lappenelephantiasis," Esmarch, etc.

The tumor, as a rule, first appears in young adult life, often after trauma. Its starting-point may be a pre-existing fibroma molluscum or a congenital patch of pigmentation. It is first evidenced by a thickening and loosening of the subcutaneous tissues, so that the scalp may be moved with greater readiness upon the skull. Finally, of its own weight, it begins to sag, drawing down the outer canthus and crowding the pinna downward until the ear stands out perpendicular to the skull (Figs. 6 and 7), or becomes buried altogether under the hanging folds of the tumor mass, which may even reach as low as the shoulder. The hair over it becomes coarse and the skin roughened; it is difficult to keep the mass clean, owing to its folds and creases; ulcerations may result, and in advanced cases, with involvement of the eyelids, there is particular risk of losing the globe from suppuration. The tumors are painless and when uncomplicated by infection or degeneration—for they may become sarcomatous—may be carried for years, though reaching an enormous size.

Pathologically they are made up of a snarl of nerve-fibers whose perineural sheaths have become greatly and irregularly thickened from an increase of fibrous tissue. The plexiform meshwork is encased in a loose, succulent, fibrous tissue, which for a long time led investigators to overlook the important part played by the nerves themselves in the make-up of these tumors.

Their recognition is not difficult, and once seen and handled they are never forgotten. The loose, flaccid tissue with its contained tangle of irregularly lobulated, cord-like masses has been likened to the feel of an atrophic and pendulous mamma. The diagnosis is easy even in the absence of other skin lesions common to the disease.

FIGS. 6 and 7.—EARLY CASE OF TEMPORAL ELEPHANTIASIS NERVORUM WITH RECKLINGHAUSEN'S DISEASE.

Showing displacement of eyelids and ear from slipping of scalp; also replacement of the same on gathering up into a fold the main part of the loose tumor mass.

Unless too far advanced or too widespread, their *treatment* should consist of early removal. They rarely if ever extend below the aponeurotic membrane and may be completely extirpated. The chief dangers lie in the possibility of infection—for the surface may be hard to render aseptic—and in hemorrhage, particularly if only a partial removal can be attempted at one sitting, since they are apt to be vascular and the vessels in the spongy tissues will not hold clamps. Cases have been reported by Billroth and others in which a great number of separate operations were undertaken before complete removal was accomplished.

Non-neoplastic Swellings.—These may be formed by extracranial collections of air, of blood, or of cerebrospinal fluid, and though primarily due to lesions of the cranium or cranium and dura as well, their chief manifestation is a soft, dome-like swelling under the scalp.

Pneumatocele Cranii.—This term was proposed by Chevance de Wassy as an appropriate designation for certain rare gaseous tumors which appear under the scalp in connection either with the air-containing cells of the mastoid process (P. occipitalis) or with the frontal sinuses (P. sincipitalis). McArthur, in 1905, was able to collect 33 cases, of which number 23 arose from the mastoid; 10 from the frontal spaces. The patient often gives an antecedent history either of direct violence or infection, which has destroyed the thin skull of bone under the pericranium without injuring the membrane itself. A sudden increase in pressure within the buccal or nasal cavity, transmitted by the Eustachian tube to the mastoid cells or by the infundibulum to the frontal sinuses, will serve to detach and blow out the covering membrane. This has occurred suddenly after a violent sneeze.

FIG. 8.—BILATERAL SINCIPITAL PNEUMATOCELE FOLLOWING TRAUMA AND INFECTION. (J. Mason Warren's case.)

FIG. 9.—LEFT OCCIPITAL PNEUMATOCELE. (L. L. McArthur's case.)

When once started the swellings progressively enlarge under successive inflations, from swallowing, blowing the nose, etc. The affection may be bilateral even in the occipital form; it is commonly so in case the

frontal sinuses are involved, when a double tumor with a median furrow is present (Fig. 8). Over the occiput the tumor may assume large proportions and have a most irregular form, owing to the variability in strength of the periosteal attachment (Fig. 9). The condition is easy of recognition, owing to the tympanitic tumor, whose walls are more or less crepitant, from the fact that some delicate spicules of bone are formed by the displaced pericranium. In some cases the swellings may be reducible and can be reinflated by the patient. These conditions are to be distinguished from acute emphysema of the scalp, in which, after fracture involving the sinuses, air may spread widely in the subaponeurotic layer and give the characteristic crackling sensation on palpation. This is a transient phenomenon.

Various forms of treatment have been advocated, as compression, puncture, injection of irritating substances, opening and packing, or osteoplastic resections. The modern surgical treatment should consist of the free opening of the tumor; the breaking down or removal of the spiculated new bone formation, possibly of fresh denudation of the separated surfaces; after which the replacement of the elevated soft parts under the pressure of a bandage should cause them to adhere. If the process has been complicated by infection it should be treated by free incision and drainage.

Sinus Pericranii (Stromeyer) *Varix Simplex Communicans.*—Under these and other terms have been described collections of fluid blood, making a cyst-like tumor, usually situated near the mid-line of the skull and under the pericranium. They are often of traumatic origin and the extracranial sac communicates with the longitudinal sinus by a channel through the calvarium. The protrusion is rarely larger than half a walnut and makes a soft, elastic swelling, reducible on pressure. Any posture which causes intracranial venous stasis, compression of the vessels of the neck, coughing or straining, tends to increase the size and tension of the swelling. Two cases of this sort, traumatic in origin, have come under my observation at the Johns Hopkins Hospital. In one of them not only was there a central swelling present, but large dilated vessels radiated from it to the frontal and occipital regions. In both the process was associated with a slow-growing brain tumor, and the intracranial stasis had presumably led to the widening of an emissary vein and the production of a dilated venous sac in the mid-sagittal line. The swelling disappeared in both of these cases when the circulatory condition had been readjusted by a decompressive craniectomy.

Meningocele Spuria.—Collections of cerebrospinal fluid as acute or chronic processes may lead to local swellings of the scalp, which at times may be difficult of diagnosis.[1] It is necessary for their production

[1] By inadvertence the authors of some of our standard text-books have given the term "Pott's puffy tumor" as a synonym for spurious meningocele. The puffy tumor which Pott described in such detail in his *Observations on Injuries of the Head* is the result of an acute, local, traumatic osteomyelitis, which leads to the formation of a subpericranial as well as to an extradural collection of pus.

that there be a lesion both of the bone and the underlying dura. As an acute process such a condition may be a complication of simple linear fractures, and from his personal experience the author is led to believe that they occur most often in children, especially after bursting fractures which forcibly separate the sutures; for at this age the dura remains attached with particular firmness to the edges of the growing bones and is torn in such injuries, so that the cerebrospinal fluid may escape under the scalp, even though the bones spring back to their original position. I have operated upon one such case two weeks after the injury, under the belief that we had to do with an extensive subaponeurotic blood-clot which did not promise to become absorbed. After evacuation of the fluid, pressure upon the detached scalp caused it to adhere without reaccumulation of the fluid. Doubtless most of these cases recover of themselves when the edges of the separated bones firmly reunite, but it is conceivable that a permanent communication may become established, owing to the tendency—from traumatic cerebral edema—for fluid to be secreted in abnormal quantity for a long time after such cranial injuries.

The *chronic spurious meningocele* of Billroth—for which Bergmann preferred the term *cephalohydrocele traumatica*—consists of a localized extracranial collection of cerebrospinal fluid which retains a permanent connection with the subdural space. The injury which has led to such a condition often dates back to birth, when it was occasioned by a difficult labor and instrumental traumatism: hence the lesion not infrequently is associated with the cerebral defects which are included under the so-called "birth palsies," so that communication with a porencephalic cavity or even with the ventricle may be present. I have seen one instance of small postoperative spurious meningocele in a baby who had been operated upon for birth hemorrhage. These tumors may persist throughout life as fluctuating, dome-like swellings (Fig. 10). They pulsate synchronously with the heart and respiration; their contents are reducible with the production of acute compression phenomena; they become tense when there is any stasis of the intracranial circulation, and give other indubitable evidences of a fluid tumor having a communication with the cranial cavity. After pressure has emptied these swellings the opening in the bone may, in some cases, be palpated; the defect is usually over the parietal or frontal regions.

FIG. 10.—CHRONIC SPURIOUS MENINGOCELE OF BILLROTH. (Bayerthal's case.)

Without aspiration it may be impossible to distinguish these swellings from sinus pericranii, but the latter are more apt to be mesially placed, rarely attain the same proportions, and no symptoms attend their reduction. Some of these cases have been operated upon and an attempt made to close the defect in the skull by an osteoplastic procedure. For the reason that some abnormality of the cerebrospinal fluid circulation must be an element in causing the persistence of these swellings, operation is usually contra-indicated or, if attempted, is rarely attended with success. It is interesting to compare this condition, which has resulted from accidental causes, with that which some surgeons have ineffectually attempted to bring about as a method of cure for hydrocephalus.

Tumors.—Sebaceous Cysts (*Wen; Atheroma*).—The scalp is the favorite seat for these retention cysts, and they are the most common form of tumor in this situation. Obstruction of the orifices of the sebaceous glands or hair-follicles (Chiari) leads to their development, and the cyst contains desquamated epithelium and fatty sebaceous *débris*. Statistics show them to be especially common in women past middle age; they rarely occur before the fifteenth year.

They vary greatly in size (from a pea to a fist in exceptional cases); they may occur singly or the scalp may be crowded with them; 22 have been removed from a single head at one sitting (Poncet). They are apt to be dome-shaped, and as the skin over them becomes thinned the hair-follicles atrophy, so that unsightly bald prominences result. Their summit may be the seat of comedo, which may be helpful in diagnosis, and the shiny, stretched skin has a bluish, congested appearance. The walls of adjoining cysts may coalesce through pressure. Depending on their size, tension, and the character of the contents, they are hard or soft and fluctuating. They occasion no discomfort unless inflamed. When once infected they swell, become tender, the contents liquefy; they rupture and discharge, and the process subsides, to be repeated over and over again. Malignant degeneration has been known to occur in their walls.

They are to be distinguished from dermoids and atheromatous cysts of congenital anlage.

If unsightly, infected, or troublesome in any way, they should be removed, care being taken in the operation not to rupture the cyst and not to carry the extirpation below the galea; and also not to seal the incision too tightly, as infection of the wound is common. Local anesthesia will suffice.

Dermoids, unlike wens, occur singly and in the young. Being due to developmental faults in the process of closure of the embryonal clefts, they are found most often in definite situations about the face and neck. They are especially common in or near the orbit, at the glabella or external angular process of the frontal, whence they occasionally extend into the temporal region; more rarely they occur over the mastoid process or in the mid-line over one of the fontanels. These dermoids about the cranium are usually deep-seated, having a close attachment

to the pericranium, and lie in saucer-shaped depressions of bone. There may even be defects, so that pulsation is transmitted to the cysts.

They are lined by true epithelium, often with all the characteristics of normal skin; their content is usually atheromatous, like that of wens. They are usually easily distinguished by their situation and immovability, from sebaceous cysts, fatty tumors, etc., but it is sometimes impossible, without aspiration, to differentiate them, especially when pulsating, from glabellar or orbital cephaloceles.

They should be removed early in life to avoid pressure deformities in the neighboring bone. Care must be taken not to open the dura. When deep in the orbit a resection operation may be necessary.

Lipoma.—This condition is rare as a primary growth, though the diffuse symmetrical lipomata of the neck may extend to some extent on to the occipital region. Grosch, in a record of 685 lipomata, found only 2 per cent. on the scalp.

They usually form flat, disk-like, semifluctuating, unlobulated tumors having broad bases. They lie, as a rule, under the occipitofrontal aponeurosis and often appear to occupy depressions in the bone. They rarely become pedunculated; they may be mistaken for dermoids or wens, chronic tuberculous abscesses or cephalocele,—and it is to be remembered that a fatty tumor often overlies certain forms of cephalocele.

They may easily be excised if troublesome.

Fibrous Growths.—True fibromata on the scalp are so uncommon that their occurrence is questioned by some writers. They may occur,

FIGS. 11 and 12.—FIBROMA OF SCALP. (W. S. Halsted's case.)

however, attain a remarkable size, and assume unusual forms, as shown in Figs. 11 and 12. This slow-growing, mushroom tumor—slightly movable with the aponeurosis, of stony hardness, covered by a thin,

hairless epithelium—was perched on the patient's head like a solid "Tam o' Shanter." It was removed by Dr. Halsted and the denuded pericranium immediately and successfully covered with Thiersch grafts. Histologically it was a pure fibroma.

The **neurofibromata** have been described under elephantiasis nervorum. **Keloids** are common upon the scalp, particularly in the suboccipital region and in the colored race (Fig. 13). They usually are an overgrowth of the scars of old furuncles and may attain a large size.

Fig. 13.—Suboccipital Keloid.

Malignant tumors may arise as primary or as metastatic growths. Either form may originate in the bone and involve the scalp secondarily. Even the meninges may have been the starting-point of certain of the fungating growths of the scalp. Primary tumors of various forms—epithelioma, adenoma, endothelioma, or sarcoma—may arise from papillomatous warts or congenital moles, which after long quiescence may be started into activity by injury or, after middle life, often without assignable cause.

There are numerous well-recognized forms of *sarcoma*, which have been variously classified according to clinical or histological charac-

Fig. 14.—Spindle-cell Sarcoma Arising in Traumatic Scar.
Twice recurrent after operation; death after five years with metastases. (The Johns Hopkins Hospital.)

teristics. They may appear as elevated, soft, nodular tumors, with overhanging edges and a more or less ulcerated surface, which do not deeply invade the tissues and do not tend to recur after thorough removal. Another type—more rapid in its growth, softer, more easily

FIG. 15.—PAPILLOMATOUS EPITHELIOMA OF BROW, RECURRENT AFTER OPERATION. (Johns Hopkins Hospital.)

bleeding—is unfavorable,owing to its rapid extension to deeper structures and to its early metastasis (Fig. 14). Melanotic sarcomata arising from pigmented moles give an especially bad prognosis for these reasons.

FIG. 16.—FUNGATING EPITHELIOMA ARISING FROM SCAR OF OLD BURN. (Johns Hopkins Hospital.)

Pulsating sarcomata, arising from the perithelial cells of hypertrophied blood-vessels, occur; and simple angiomata (p. 28) may metamorphose into tumors of this character.

Epithelioma of malignant form may arise from papillomatous warts (Fig. 15) or other excrescences on the head which have been subjected to injury; or in old cicatrices (Fig. 16) or unhealed ulcers on the scalp.

FIG. 17.—CARCINOMA CUBOCELLULARE; TWENTY YEARS DURATION. Rapid fungating growth for eight months. (Johns Hopkins Hospital.)

There have been many attempts to satisfactorily classify these "skin cancers," the recent terminology suggested by Krompecher being

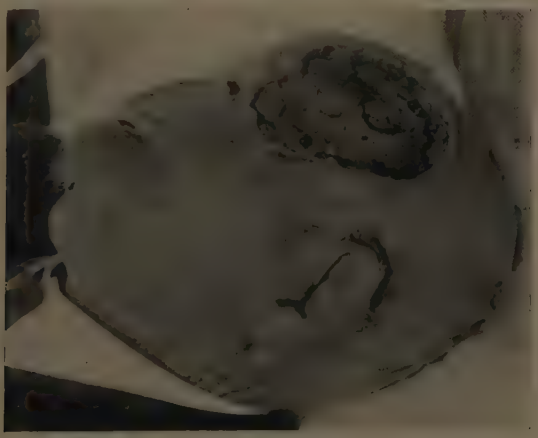

FIG. 18.—DEEPLY ULCERATING AND INOPERABLE CARCINOMA SPINOCELLULARE. RECURRENT AFTER OPERATION. (Johns Hopkins Hospital.)

regarded by Bloodgood as the most practical. He divides them, according to their origin from the cells of one or another of the three epithelial layers, into basocellular, spinocellular, and cubocellular carcinomata. Any one of these types may lead clinically to a fungating (Fig. 17) or ulcerating (Fig. 18) form of tumor. They include many growths formerly regarded as sarcomata or endotheliomata.

Tuberculous and **syphilitic disease of the soft parts** is usually secondary to disease of the bones.

In this, as in the succeeding lists of references, merely some of the more recent or comprehensive articles are cited, which in themselves contain more or less complete bibliographies.

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PART II.

THE CRANIUM.

"It may be difficult in all cases of local disease to distinguish between one truly local and one arising from the constitution; that is, one arising entirely in the part diseased and one arising entirely in the constitution."

* * * * * *

"Unluckily for bones, they can hardly swell; nor can their coverings swell without its being immediately suspected as venereal, so that mercury is often given to the detriment of the patient."—JOHN HUNTER, *Principles of Surgery.*

Anatomic Considerations.—The skull at birth is necessarily adapted to undergo changes in form during its passage through the parturient canal. This applies in particular to the vault, where the individual bones laid down in the original membranous covering of the brain are not only pliable, but have not, as yet, become united. The

primary centers of ossification for these thin, vascular shells have separated the membrane into an outer pericranial and inner dural lining. Both of these layers play an active part in bone formation during the early years of life; whereas, later on the dura largely loses this function. Growth from the centers of ossification takes place radially, a characteristic which influences the direction assumed by lines of fracture in the infantile skull (Fig. 55). Even after the membranous interspaces become completely filled in, ossification continues from the edges as well as from the membranous coverings, so that there is an increase in thickness as well as in size. As the bony deposit thickens, the medulla-like diploe is formed, leaving layers of denser bone under each membrane—the outer and inner tables.

Any form of external pressure, long continued, tends even after birth to mold the skull into abnormal positions, as evidenced by certain tribal deformations and by the flattening which follows long-continued lying in an unchanged position. Even remote external influences may affect the cranial configuration—congenital wry-neck, for example, in which there is a tendency for the tilted skull to straighten itself, and the resulting obliquity of the orbital plates and even of the vault itself is especially noticeable after division of the contracted muscle. None of these things, however, influences the amount of intracranial space and the brain may develop to its normal size and weight though its form may have been modified.

On the other hand, pressure from within plays a still more important rôle, for if these external influences be removed before final solidification, the skull will quickly round out again into the form to which it was normally destined. Further, intracranial abnormalities, leading either to an increase, as in hydrocephalus, or a diminution of pressure when there are encephalic defects, affect the size and shape of the skull. Thus, a defective area from a lesion occurring early in life often leads to a local flattening, so that its seat may be recognized by external configuration alone. Thus, though extracranial as well as intracranial conditions may modify the form of the skull, intracranial conditions alone are responsible for the size of the chamber. The final firm closure of the sutures does not take place until the fourth or fifth year, though progressive cranial enlargement continues until adult life. With advancing years the bones become denser, less vascular, the serrated lines of suture may disappear, the diploetic layer lessens in amount, and the senile, brittle skull finally results.

Though much stress was laid in earlier days upon the position and number of the sutures, our present interest in them lies mainly in the fact that they may be mistaken for fractures when none exist; that fractures may be guided into them; and that they may become separated in the young in consequence of injury or intracranial disease. This is another instance of the effect on the skull of intracranial processes, for even after apparently solid union a sufficient increase in pressure from within may separate the bones, even up to the twelfth year, as I have seen in one instance.

There is great variation in density and thickness, not only between different skulls, but in different areas of the same skull. In one there may be a heavy, dense vault, 1 cm. in thickness and most difficult to enter; in another, an equally thick, but a soft, porous, and vascular bone which cuts or saws easily; or again, merely a thin, fragile covering. As we approach the cranial base the brain is less well protected by bone, though better protected by other structures. The thin temporal regions are covered by muscle and guarded by the arch of the zygoma; the occipital base by the strong attachments of the cervical muscles; and the thin plates of bone constituting the fossæ are quite inaccessible to direct violence, though frequently implicated by indirect injuries. However, owing to its bizarre structure, its perforation by numerous foramina, its air-containing cells and the arrangements for the special sense organs, disease processes are more common here, just as traumatic lesions are common on the exposed vault.

The diploe varies greatly in its degree of vascularity. It may—particularly in chronic conditions of venous stasis—possess large sinuses or, on the other hand, it may be comparatively bloodless. At the parietal, mastoid, and occipital protuberances the bones are perforated by channels for emissary veins which connect the dural sinuses either with diploetic or extracranial vessels. The inner surface of the skull shows the impression not only of the meningeal artery, which may even canalize the bone in a part of its course, but also of the lateral and sagittal sinuses. Particularly is this true of the latter and of its broad lacunæ laterales, into which the Pacchionian granulations project.

DISEASES OF THE CRANIAL BONES.

Disturbances of Growth.—There are a number of conditions, accompanied either by an absorption or by an overgrowth of bone, which, though not amenable to surgical measures, need, for diagnostic reasons, to be borne in mind.

(1) **Processes accompanied by atrophy** may either be due to local conditions or to general nutritional disturbances. Simple pressure, as from an overgrowth of Pacchionian bodies, or even from stasis in the venous channels, may lead to local atrophy. An intracranial tumor, even without invasion of the overlying skull, may cause its absorption by continued pressure, and thus "decompression" may occur by natural processes. External tumors, like dermoids, are particularly apt to cause a thinning of the underlying bone.

Senile Atrophy (*Anostosis Cranii*).—As described by Rokitansky and Lobstein, a symmetrical absorption of bone, beginning in the diploe and extending to the outer table, may occur in the skulls of old people. This leads to bilateral depressions usually situated over the parietal regions (Fig. 19). The process may start from various centers, which finally coalesce, producing the so-called eccentric atrophy, often leaving the bone of paper thinness or with actual defects.

Hemifacial atrophy, presumably a nutritional disturbance due to

a lesion of the trigeminal nerve, may lead not only to the unilateral absorption of bone, but of the overlying soft parts as well. The bones of the face are more apt to be affected than those above the brow.

The Atrophy of Rickets.—In this constitutional disease due to impaired nutrition, alterations in the cranial bones are especially pronounced. Elsässer, in 1843, introduced the term *craniotabes*, commonly used in designation of the yielding, parchment-like patches of atrophy, so frequently found in the parieto-occipital region.

The cranial changes are not limited to these areas of absorption, but particularly over the parietal and frontal eminences overgrowth may occur. This, with the pressure deformity from lying, gives

FIG. 19.—SKULL SHOWING FLAT SYMMETRICAL DEPRESSIONS OF BOTH PARIETAL BONES. Due to senile atrophy. (Kindness of C. A. Hamann, Western Reserve Medical School.)

to the head its characteristic cuboidal form. The fontanels are slow in closing and when craniotabes is present the picture may suggest hydrocephalus. The two conditions, in fact, are not infrequently combined, for malnutrition is common in congenital hydrocephalus, but there should be no difficulty in differentiating them. Rickets merely modifies hydrocephalus; it does not create it.

Fetal rickets (*achondroplasia* or *chondrodystrophia fœtalis* of Kaufmann) is a dystrophy of the epiphyseal cartilages of the long bones, affecting their growth through premature union; the bones laid down in a membranous matrix remain largely exempt from any alteration and the head consequently retains its normal proportions.

Osteogenesis imperfecta (*aplasia cranii*) is a failure of normal osseous development rather than an atrophy of bone. It is a systemic

disease of the fetus, accompanied by marked fragility of the bones and intrauterine fractures may have occurred. The defective development of the cranium is especially marked (Fig. 20) and the posterior aspects of the skull may consist of little more than membrane containing small plates of bone. Looser's recent studies have shown that the skeletal changes are the same as in the so-called idiopathic fragilitas osseum. (See also Vol. II., pp. 51–54.)

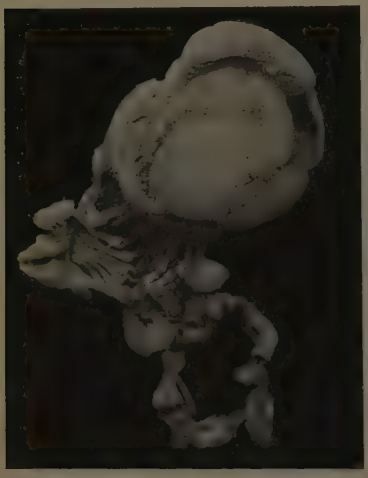

FIG. 20.—APLASIA CRANII WITH OSTEOGENESIS IMPERFECTA. (Surgeon General's Museum.)

In these and in other diseases, like *fetal myxedema, congenital syphilis*, etc., not only may there be deformation of the skull, large fontanels, depressible margins of the flat bones along the sutures, but craniotabes as well. This, therefore, cannot be regarded as peculiar to rachitis and hydrocephalus; and patchy atrophy of the skull, giving similar physical signs, may, indeed, be present in perfectly normal infants. Our present knowledge of the epiphyseal changes in the long bones, in the recognition of which we are materially aided by the *x*-rays, enables us to distinguish many of these nutritional affections.

The *treatment* of most of them is purely dietetic, hygienic and medicinal; and surgical measures, except for the reduction of associated deformities in the long bones, are rarely indicated. When craniotabes is present frequent changes in position and a soft support for the head are necessary.

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(2) **Processes Accompanied by Hypertrophy.**—Here again systemic disturbances or purely local processes may lead to the alteration in growth. Among the latter causes chronic inflammations are the most common, and certain varieties of tumor lead to marked periosteal overgrowth.

Cases of general hypertrophy of the skull have been described, due to a symmetrical enlargement of the cranial bones—"*Riesenwuch.*" Another form of overgrowth, unassociated with change in external configuration, is due to a condensation of tissue with obliteration of the

cancellous diploë and sutures. It is a general process, affecting all of the flat bones alike, and is not limited to areas, as is the chronic ostitis secondary to inflammation.

Allan Starr has recently reported the case of a woman who presented a slowly progressive increase in the size of the head, face, and neck, the bones and soft parts alike being affected. He applied to the condition the term *megalocephaly*.

Acromegaly.—This remarkable malady, first described by Marie in 1886, is characterized by a general skeletal hypertrophy and, in a lesser degree, by some thickening of the soft parts. (See Vol. II., p. 64.) The changes, which usually begin in young adult life in association with tumor, hypertrophy, sclerosis, or cyst formation of the hypophysis cerebri, are particularly apparent in the face and head, and when once the acromegalic type is in mind the familiar resemblance that all cases bear toward one another makes the disease usually recognizable at a glance. The undershot jaw, the prominence of the cheek, the nasal bones and supra-orbital ridges, with the thick lips and the large, full nose, give an exceptional facies, which, taken with the "spade-like" hands and feet, the broadening of the terminal phalanges shown by the *x*-ray, the round-shouldered back, set the disease apart from all others. Occasionally these individuals suffer frightfully from headaches, and it is presumable that when the physiology of the hypophysis is better understood and an operative approach to it perfected, that many of these cases will be treated surgically.

Leontiasis ossea of Virchow (*hyperostosis cranii*) is a chronic disease affecting almost exclusively the bones of the skull and face. Either the cranial or the facial bones alone may be involved. Its etiology is unknown. In a young adult dense, osseous masses begin insidiously and painlessly to heap themselves up on the normal bony surfaces until the face is robbed of all human proportions. The nasal cavities become blocked; the orbits become narrowed, so that the globes protrude and blindness results; the cranial bones also are invaded and may become many times their normal thickness. Though the enlargement usually takes place in an outward direction, it may progress inward as well, so that the cranial chamber becomes narrowed and headache, convulsions, paralyses, or mental disturbances result. In milder forms the disease may progress for years and be not incompatible with a fair degree of health, until obliteration of the accessory cavities lodging the special sense faculties advances to such a degree that inanition and even death from starvation may result. The total weight of the skull may reach seven or eight times the normal, and though the disease is rare, few large museums fail to possess specimens, photographs of the more notable of which have been often reproduced.

Except for an occasional symptomatic measure this malady is beyond medicinal or surgical treatment. Horsley has done palliative operations in cases when pain has been produced by entanglement in the growth of the trigeminal branches, and has removed large masses of the exostoses.

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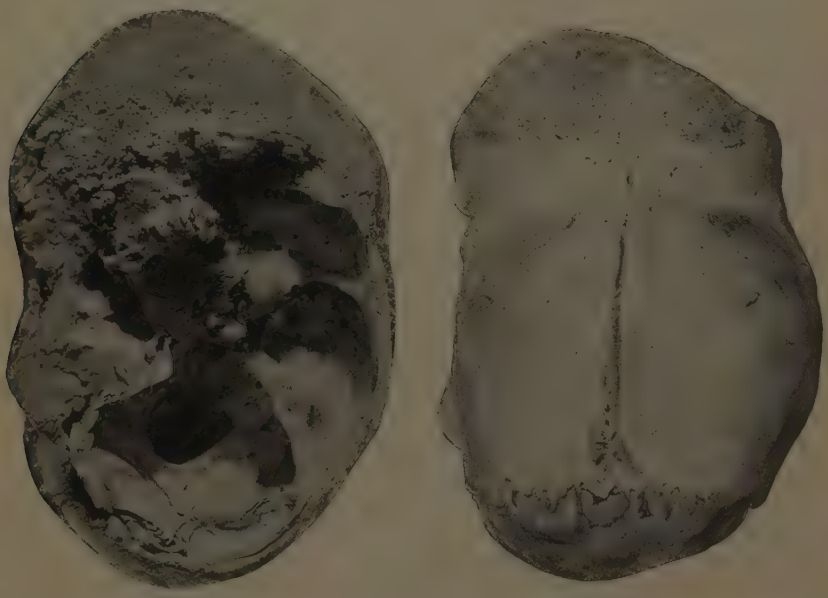
Gigantism belongs in the same category with the above and is not infrequently combined with unmistakable evidences either of acromegaly (50 per cent. of cases) or leontiasis ossea. Some authors have even gone so far as to say that they are simply different expressions of the same morbid condition; that acromegaly is merely delayed gigantism. Gigantism, in other words, occurs when the process starts in youth;



FIGS. 21 and 22.—SKULL OF THE GIANT WILKINS.
Showing enormous overgrowth largely limited to the frontal bone; sarcomatous degeneration. (Kindness of Peter Bassoe.)

acromegalia, in adult life: and when the process starts in youth and continues to adult life, a combination of the two is found. In both maladies a lesion of the pituitary body has usually been found, and though physiologists have not as yet agreed on the function of this gland (Cyon's experimental observations were quite negative so far as growth was concerned), it nevertheless seems to have some presiding influence, at least upon skeletal growth.

A number of these giants have been described. They are, as a rule, shortlived, rarely surviving more than twenty-five years. The presence of cranial hyperostosis is especially well shown in the case of the giant

Wilkins described by Bassoe (Figs. 21 and 22). The enormous overgrowth of bone, particularly of the frontal region, with exostoses and compression defects of the cerebrum, are well shown. As occurred in this case, the cranial hyperostoses may become sarcomatous.

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Osteitis deformans (Paget) is another disease of the bones which has some interrelation with the maladies just mentioned. (See also Vol. II., p. 60.) Unlike gigantism, it shortens stature rather than life. It is a rare disease of unknown etiology, occurring in middle age and affecting males preponderantly. It affects, by a symmetrical process of hypertrophy, the long bones of the lower extremities, the spine, and skull. It is characterized by bowing of the long bones and curvature of the spine. The disease may be confounded with rickets and osteomalacia. In the skull—unlike acromegaly and gigantism—the enlargement is limited to the cranial vault, without participation of the bones of the face. The hypertrophy is an eccentric one, rarely accompanied by encroachment on the intracranial space. The bones become thickened and lead to a projection of frontal, temporal, and occipital regions, giving the head its characteristic top-heavy appearance. Nodular irregularities sometimes appear upon the surface due to an asymmetrical overgrowth.

Osteomalacia.—Only in severe cases do the bones of the skull become involved in the process. The softening is due to the removal of lime salts and leads to deformation and fragility of the bones. The condition is best known in its puerperal form. (See also Vol. II., p. 57.)

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Infectious Processes. — Osteomyelitis (*ostitis* and *periostitis*) may occur as an acute or chronic process in the flat bones of the skull. The acute abscesses due to coccal infections are less common here than in epiphyseal bones, in which their occurrence was first recognized; and the greater number of cranial infections are originally subperiosteal and involve the bone secondarily. (See also Vol. II., p. 29.)

An acute periosteal inflammation (*acute pericranitis*) is common in open infected wounds when the pericranium has been stripped away; and also after contusions, even when there remains an unbroken scalp, a subperiosteal abscess may develop. Collections of blood under the pericranium (cephalhematoma) may become infected, leading to subpericranial abscesses, and these, unless opened promptly, often lead in turn to secondary changes in the bone. Occasionally acute infectious

diseases may be complicated by subpericranial abscesses, and they are a frequent sequel of infection in the mastoid cells or frontal sinuses when perforation has occurred and the pus spreads out under the periosteal covering.

Acute osteomyelitis, with its chronic sequelæ of periosteal thickening, sequestrum formation, etc., so characteristic of medullary abscesses in the long bones, rarely occurs in its typical form as a primary process in the skull. This is due to the absence of cartilaginous epiphyses as well as of isolated foramina and terminal vessels, which favor the lodgment of bacteria at the ends of the long bones; and further, the scant diploë has no such functional activity as has the marrow of the long bones.

Spontaneous diploëtic infections, however, of staphylococcal origin apparently do occur, associated with the general constitutional symptoms of acute osteomyelitis in other situations and followed by a local abscess and the final discharge of a sequestrum; but whether the process is comparable to the epiphyseal infections may be disputed. The local acute osteomyelitis following contusions and leading to general febrile symptoms was so graphically described by Percival Pott that in the English speaking world it retains his name to this day—"Pott's puffy tumor." In the absence of any conception of bacterial invasion he nevertheless recognized the central necrosis which not only could lead to an external collection of pus, but to a subcranial extension as well, so that the suppurative process might assume a collar-button shape. In these traumatic cases it is presumable that there is some point of entry for micro-organisms, possibly small and at a distance, the organism getting into the blood stream and lodging in the tissues at the contused area, where there is diminished bacterial resistance.

Osteomyelitis which follows cellulitis after lacerated scalp wounds is quite a different process from these blind infections and is perhaps less likely to lead to intracranial complications. The resulting necrosis of the bared and infected bone may be extensive; large areas either of the outer table alone or of the entire thickness of the calvarium may become sequestrated and lost.

Suppurative osteomyelitis may be a particularly serious malady if there is a tendency for the disease to extend into the subcranial tissues. There is always a danger of meningitis, sinus phlebitis, or cerebral abscess when once the intracranial chamber is invaded, and death from any one of these or from pyemia may be the sequel. The complications and the manner of their extension are much the same as those which arise from middle-ear infections, and it may be said of both that prompt and early drainage down to the dura, the moment signs of spreading infection appear, will usually ward off all subsequent trouble.

Chronic osteomyelitis may grow out of these acute processes. An extensive necrosis may occur with continued suppuration which attends the sequestration of bone and the tedious repair of such wounds. There is little tendency for the separating shell of bone to become enclosed, owing to the slight osteogenic power of its coverings, and, before it finally becomes loosened, discharge from the surrounding granulation

tissue may persist for years. The history and the acute onset of the trouble serve to distinguish chronic bone lesions of this type from tuberculous or syphilitic processes, even though the local appearances may at times closely simulate one another.

Extensive sequestration of the skull may follow charring burns of the scalp. Though the necrosis is usually restricted to the outer table, the entire thickness may be involved. A most remarkable case, in which almost the entire vault was exfoliated in one piece, has been recorded by Keen. Cases have also been reported by Kirkead, Broca, and others.

The *treatment* of the acute abscesses should consist of early and free incision down to the bone, and in case there is any suggestion of deeper trouble trepanation is necessary, in order to ascertain the condition of the dura. The wound should be left open and drained. When necrosis has occurred the operator, after the first thorough drainage, must wait until there is some evidence of demarcation—not until the entire area has become loosened, but until its outlines are clearly apparent. After removing most of the bone evidently diseased, the edges must then be rongeured away to undoubtedly healthy tissue, and it is to be noted that the necrosis often involves the inner more widely than the outer table. The wound is then packed until granulations form, after which its edges may be allowed to fall together. At times the defect may be closed by an osteoplastic flap containing a shell of the outer table from an adjoining area, and thus a complete bony calvarium may be restored. As a matter of fact, however, the defect, unless it is disfiguring, is harmless and does not need any such repair.

Cranial syphilis usually manifests itself as a gummatous inflammation of the pericranium; less commonly of the diploë. Cranial lesions may be present in hereditary syphilis, though the osteochondritis of the long bones is of more usual occurrence. The lesions of these luetic infants are fairly alive with the spirochæta pallida. As a late manifestation of acquired syphilis, gummata often appear upon the frontal region as tender, elastic, slightly elevated swellings, over which the scalp may move freely. They often follow local injuries and are mistaken by patients for traumatic swellings and by their attendants for a variety of processes—sarcoma of the skull, subpericranial abscess, etc. These chronic, painless swellings rarely attain a large size; they are often multiple. When left to themselves, as the luetic inflammation leads to a productive growth of the bone, they may cause a slight, permanent, local thickening of the skull. They usually subside under a vigorous antiluetic régime and may even disappear spontaneously.

In other cases, however, the process is progressive and may lead to remarkable changes in the bone. The gummatous inflammation may spread widely in the diploë and over the surface of the skull, leading to a true syphilitic ostitis. The Haversian canals become enlarged and, hand in hand, there occurs not only absorption, but a reactionary overproduction of bone, often of ivory hardness; and ultimately the calvarium in patches or over wide surfaces becomes irregular to a degree,

and presents, in the macerated specimen, the worm-eaten appearance so well known. Even in this stage the process is amenable to medicinal measures alone, though when arrested the surface irregularities remain permanently palpable through the scalp.

More serious symptoms result from infection of the soft gummatous tissue, a change to which it is most prone. The scalp then becomes thinned, reddened, breaks down, and discharges the disorganized gummatous material. Chronic ulcers with ragged undermined edges form, exposing areas of the more or less honeycombed bone (Fig. 23). The suppuration spreads into the new tissue which has infiltrated the bone and dry, irregular sequestra lie exposed. Large portions of the

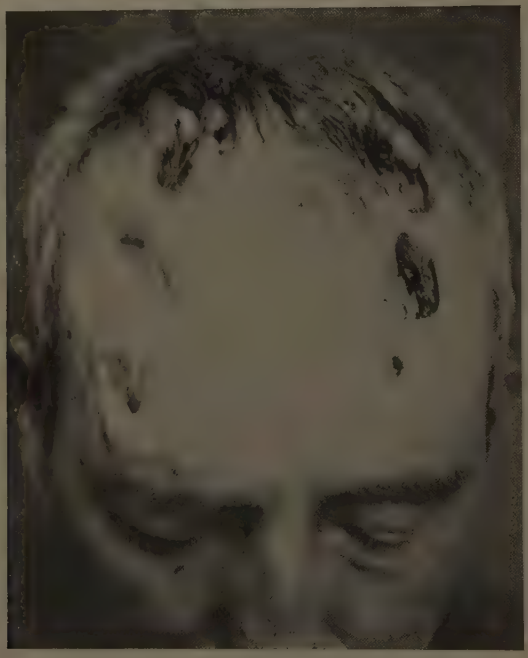

FIG. 23.—CHARACTERISTIC EXTERNAL APPEARANCE OF SUPPURATIVE SYPHILITIC OSTEOMYELITIS. (Kindness of C. A. Porter.)

skull may thus become invaded—indeed, almost the entire calvarium (Fig. 24). As necrosis spreads, a reactionary inflammation takes place at its periphery, which accounts for the coral-like irregularities of the surface. The channels through the worm-eaten bone often penetrate to the dura, so that pulsation may be transmitted to products of suppuration which lie within them; the process can hardly be mistaken for necroses of any other sort. Should healing take place large defects may be left and the resulting depressed scar—white, thin, attached, covered by dilated vessels, and surrounded by an irregular, elevated, bony ridge —tells the story even for an uncommunicative patient.

More or less intracranial pain with nocturnal exacerbations accom-

panies cranial syphilis and, owing to the chronic inflammatory changes in the dura, may persist even after the acute process has healed.

Treatment.—These widespread suppurations demand free drainage—especially when infection has extended to the dura—frequent irrigation and scrupulous cleanliness; and at the same time medicinal antiluetic measures must be pushed to their toxic limit, possibly with the hypodermic administration of mercury in some form. For better drainage it may be advisable to remove some of the external table, which may be glanced off with a chisel if the bone is eburnated or even scraped away with a sharp spoon. Too early and forcible removal of sequestra may be attended by serious consequences, for the surrounding zone of reaction

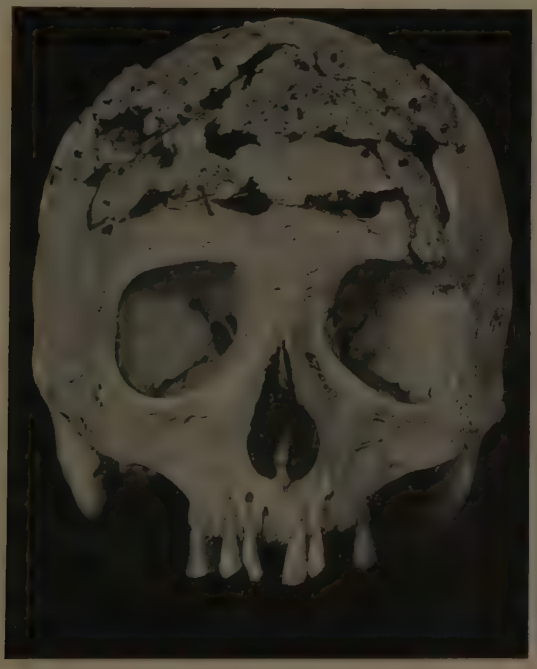

FIG. 24.—EXTENSIVE SYPHILITIC NECROSIS OF THE CALVARIUM. (Specimen in the Warren Museum of the Harvard Medical School.)

may be broken through and acute infection be superimposed on a walled-off and chronic one. There need be no hesitancy, however, in removing a well-demarcated sequestrum, and there is a remarkable tendency after such removals, even when large defects are left, for the gap to fill in by new bone. This is contrary to the usual experience in the case of acute traumatic or operative defects. It is Hofmeister's view that the dura plays the chief rôle in this new formation.

Tuberculosis occurs almost without exception in children, usually as a single circumscribed lesion of the vault; more rarely there are multiple ones. Concomitant foci of tuberculosis elsewhere in the body commonly serve as a tell-tale of the nature of the process. The disease

usually starts in the diploë, and the focus of suppuration quickly extends in the child's thin skull both externally and internally, and leads to the perforating abscess described by Virchow. The subperiosteal "cold" abscess—soft, fluctuating, covered by reddened skin—frequently opens of itself, leaving a sinus, at the bottom of which a patch of necrosed bone may be detected. A small sequestrum usually forms, separates early, and may be removed by curetment. The disease often remains limited to the external table. When neglected these tuberculous abscesses may burrow under the pericranium or aponeurosis and open at a distance, leaving fistulous tracts which are difficult to heal unless widely laid open, thoroughly cleansed, and packed. The temporal bone is the most common seat of tuberculous osteitis, the process being secondary to tuberculous otitis media or mastoiditis, as will be described in another section.

The probability of recovery depends, of course, upon the general resistance of the patient and the thoroughness with which the focus of disease may be eradicated. As Dr. Halsted has emphasized, there is the same need in surgical tuberculosis as in the pulmonary forms of the disease for general hygienic measures; for sunshine, life in the open air, and an abundance of good, nourishing food.

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Delamare and Conor: D'ostéite tuberculeuse de la voûte crânienne. Gazette des Hôpitaux, 1903, vol. lxxvi., p. 205.

Tumors of the Cranial Bones.—Osteoma.—We have seen in acromegaly, in leontiasis, and especially in gigantism that along with the general bony overgrowth there is a tendency in some cases toward the formation of irregular hyperostoses. Apart from these constitutional diseases, however, isolated neoplasms of osseous tissue may occur. They are benign tumors, and depending on their structure—whether composed of compact or of spongy bone—they are termed *Osteoma durum* or *eburnum* or *Osteoma spongiosum*. They are, furthermore, divided by their histological structure into those arising from periosteum (fibrous osteomata) and those arising from cartilage (chondral osteomata).

Since Galen, these bony outgrowths have been designated as *exostoses*, and with the exception of the chondral form they most frequently occur as outgrowths from the skull. Even chondral osteomata may occur in connection with those parts of the skull which primarily were laid down in cartilage.

As exostoses, these tumors arise from the pericranial or dural surface of the skull, and by a slow augmentation in size project under these membranes. They may be single or multiple; they may assume any form. Though, as a rule, they are flat, rounded, or knob-like projections, they may be sessile or become pedunculated, and, though rarely larger than a walnut, they may attain almost any size.

Virchow, in *Die Krankhaften Geschwülste*, has given a description of

these growths which will long remain our chief authority concerning them. Almost all of the exostoses of the vault are of the eburnated form, being composed of compact bone. They vary greatly in size, from a small, smooth, sessile nodule (Fig. 25) to large, irregular, more or less pedunculated growths, such as are figured in Volkmann's oft-reproduced drawing. As a rule, the larger the tumor the more irregular its surface becomes, though comparatively large osteomata may remain smooth and sessile (Fig. 26). The tendency of the large growths to become pedunculated may even lead to their complete separation from the bone.

External exostoses may follow trauma in case the pericranium has been stripped up or incited to overgrowth, and a deposition of new bone (myositis ossificans), comparable to the "rider's" or "hunter's bone"

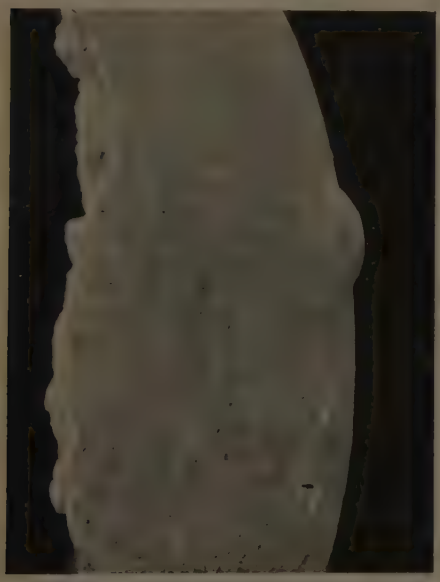

FIG. 25.—EXOSTOSIS OF PARIETAL BONE (natural size). (Surgeon General's Museum.)

FIG. 26.—FRONTAL OSTEOMA EBURNUM OF FIFTEEN YEARS' DURATION, PRODUCING NO SYMPTOMS.

of the extremities, may occur also at the seats of muscular attachment, particularly in the suboccipital region.

Exostoses similar to the above may likewise grow from the inner surface and may reach a considerable size without producing symptoms, since from their gradual increment they cause a slow deformation of the adjoining cortex. A particular form occurs as the so-called *osteophytes*, oftentimes entirely confined to the inner surface of the frontal bone (Fig. 27). They may be of variable size and number, of smooth or lobulated surface, and of delicate and spongy texture. They have been found most often during the post-mortem examination of women who have died during the puerperium. They seldom produce symptoms and presumably may become spontaneously absorbed.

True *enostoses*, or bony tumors of myelogenous origin, such as have been found within the medullary cavities of long bones, are unknown in the skull, or at least if such tumors do arise they cannot be differentiated from the exostoses which have grown through into the diploë. Certain osteomata arising from the accessory sinuses have been incorrectly termed enostoses, for though they are enclosed within spaces in the bone, they actually arise from the periosteum of the sinuses.

These *osteomata of the accessory sinuses*, ethmoidal and sphenoidal, are a special form of exostoses, to which particular attention has been called through the papers of Bornhaupt and of Tichof, who have recorded 78 cases of this rare condition. The tumors arise from the periosteal membrane lining these sinuses or from cartilaginous rests of the ethmoid

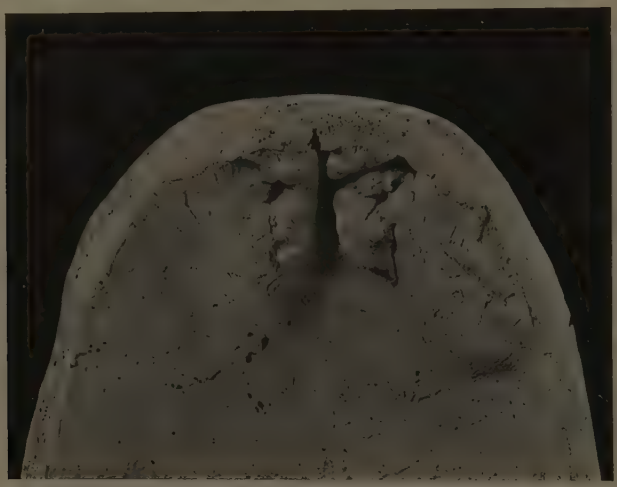

FIG. 27.—FRONTAL OSTEOPHYTES.
(Specimen from the Warren Museum.)

(chondral osteomata), and the growth finally fills the cavity, causing its walls to bulge and finally to disappear through pressure atrophy. Thus, the tumor may invade neighboring spaces—the orbit, for example—or pass through the base of the skull. These osteomata are composed of an eburnated shell covering a central spongy portion and their form depends on the amount of resistance to their growth which is exerted by the surrounding structures. They may sometimes become detached through processes of suppuration and fill the distended sinus as a foreign body. From the fact that the orbit is frequently invaded they are often spoken of as orbital exostoses.

Diagnosis.—Most cranial exostoses are easily recognized, though early in their development they may be mistaken for sarcomata. The intracranial projections, when unaccompanied by external evidences of the same process, can only be suspected by cerebral symptoms, such as might follow a local loss of cortical activity. There may be equal difficulty in recognizing the frontal and sphenoidal sinus tumors, for

until the sinuses have been opened they may be taken for sarcoma or empyema.

Treatment.—If the size of the tumor permits; if it gives symptoms of compression from intracranial invasion; if it originates in the sinuses and causes complications and deformities of the enclosing wall, or if it is in any way unsightly, it should be removed. Otherwise, considering their slow growth and their benign character, they may be safely left alone. When the tumor traverses the bone it must be removed by an incision encircling it. The prognosis of operation for frontal sinus or encapsulated osteomata is bad—or was bad when, in 1894, Chipault collected 15 cases, of which only 5 were successful. The others died of meningeal infection. Bergmann suggests that these bad results were due to the failure to understand the true nature of the encapsulation, for in a properly conducted operation it is necessary to rongeur away the wall of the cavity and expose the tumor down to its base, which should then be chiseled off. Drainage, of course, must be instituted when there is a suppurating cavity.

Parasitic cysts, though exceedingly rare, have nevertheless occurred in the crania of the young. They originate between the two tables of the skull and may reach the size of a fist. A fistula may sometimes be formed. Gangolphe, in a report of 52 cases of echinococcus cysts of the bones in general, found 4 in the cranial bones, 3 of these having occurred in the os frontalis.

The only treatment is free opening with removal of the lining membrane and packing with gauze, leaving the cavity to close by granulation.

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Gangolphe: Kystes hydatiquies des os. Thèse, Paris, 1886.

Sarcoma.—Those originating in the skull do not differ histologically from the commoner sarcomata of the long bones. They take their origin either as myelogenous growths from the diploë or as dural or periosteal tumors from the membranes, in which case there may be abundant new bone formation. The tumors may occur in any situation and are no respectors of age or sex. Indeed, a congenital osteosarcoma of the skull has been reported by Neufeld. Their cellular structure varies greatly, the spindle- and round-celled varieties being the most common form of periosteal growths, while those containing giant cells usually originate from the diploë. At times they may be highly vascular and actively pulsating (angiosarcoma). Myxosarcoma, chloroma, and cystosarcoma likewise occur.

It is remarkable how often traumatism seems to play a part, either in accelerating the growth of a pre-existing tumor or even in inciting the process, for frequently there is a history of an injury which immediately preceded the first appearance of the swelling. Certain forms may attain large proportions (Fig. 28), particularly the spindle-celled osteo-

sarcomata arising from the external cranial surface, and macerated specimens showing the spiculated, bony structure of the new growth are to be found in most pathological museums.

FIG. 28.—ENORMOUS PERIOSTEAL SARCOMA OF THE TEMPORAL REGION, WITH CERVICAL METASTASIS. (Johns Hopkins Hospital.)

A sarcoma which originates from the dura may at first give no signs other than those of an intracranial tumor, though some local tenderness of the overlying skull may be present. As time goes on the growth invades the skull, which becomes absorbed, and the tumor appears as a swelling under the scalp. This destruction of bone by invasion (Fig. 29) is quite a different process from its destruction by pressure absorption—a process which occurs in some cases of dural or brain tumors and which may lead to a temporary amelioration of the pressure symptoms in case of an opening sufficiently large to relieve the tension. A perforation, filled by the new tissue, may occur, whether the primary seat of the growth was external, internal, or in the diploë. In any case the diploë becomes invaded laterally, often to a wide extent, so that a large

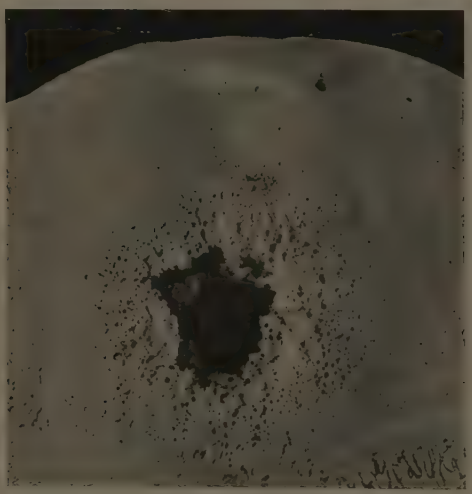

FIG. 29.—CHARACTERISTIC PERFORATION OF THE SKULL FROM INVASION OF A SARCOMA. The diploë is more widely destroyed than the tables (Warren Museum).

circle of removal becomes necessary in attempted extirpations. When these deeper growths finally appear under the scalp they form sessile, dome-like swellings (Fig. 30), as the aponeurosis resists their further extension for some time. Large subcutaneous veins radiate from the

growth through the scalp; this finally becomes involved, breaks down, and there results an infection of the denuded growth, which fungates, bleeds, and sloughs after the usual manner of large ulcerating surface sarcomata.

No form of new growth arising from any of the tissues is more serious than these bone sarcomata, and although some of the myelogenous tumors metastase late and do not tend to recur after local extirpation, this cannot be said of the commoner spindle- and round-celled forms. Their growth is usually rapid. The average duration of life is said to be not more than one or two years—a shorter time than is the cas with sarcoma elsewhere, since, in addition to the usual visceral metastasis, here, intracranial invasion often leads to death. The periosteal growths, therefore, give a better prognosis, since cerebral complications are often absent or delayed.

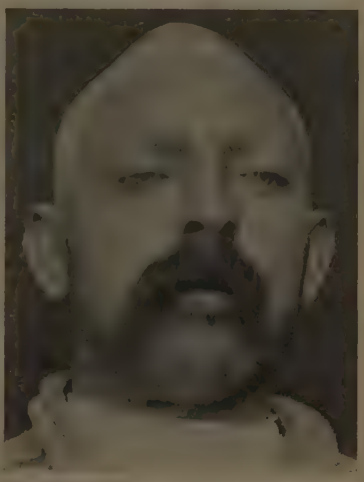

Fig. 30.—Dome-shaped, Round-celled Sarcoma of the Cranial Vertex Following Trauma.

Probable origin in the diploë; extensive lateral invasion of bone and of cranial chamber; inoperable. (Massachusetts General Hospital.)

Sarcomata of the cranial base are possibly less common than those of the vault, and usually involve the bones by extension of a process which has arisen in the accessory sinuses of the nose or in the orbit. They may develop from nasal polypi or arise as primary tumors of the sphenoid, ethmoid, or superior maxilla, and in the latter case may assume large proportions before invasion of the skull takes place. A favorite site for intracranial invasion is through the side of the sphenoidal sinus, so that the tumor underlies the Gasserian ganglion, giving rise to neuralgic pain with more or less evidence of pressure paralysis of the trigeminal and oculomotor nerves.

The *diagnosis* of sarcoma in its early and operable stage is often difficult, and the determination of its place of origin and histological variety is still more uncertain. Gummatous osteitis and periostitis may give rise to a swelling similar in consistency and form, and it must be emphasized that the failure of absorption of such a swelling after a brief though vigorous treatment should lead to operative exploration. The ossifying forms of sarcoma are often regarded as simple exostoses until advancing growth reveals their true nature.

Whether the tumor has originated in the diploë, periosteum, or dura can only be surmised, and oftentimes an intracranial extension may be unsuspected. The myelogenous tumors are supposed to lead to a separation of the external and internal tables in such a way that when the growth finally breaks through, their edges slope away from the apex of the swelling; when, on the other hand, a surface tumor has perforated

the bone by extension from below or above, the tables are not thus deformed. This cannot always be taken as an invariable sign, even if determinable during life, for the diploë may be infiltrated and the tables separated in the perforating tumors, as well as in those of diploëtic origin. This is particularly true at the only period of their growth when they are amenable to operative removal; namely, when small. Owing to the curved surface of the cranium an *x*-ray photograph, even though the tumor contain bony elements which throw shadows, will not be of any great assistance in determining the character and depth of the cranial involvement, though it may throw light on the structure of the tumor and possibly serve to distinguish a periosteal from a myelogenous growth.

It must be remembered that cranial hyperostoses may undergo sarcomatous degeneration; also that cranial sarcomata may not be primary. Hence it is necessary to carefully examine the rest of the body for a chance source of metastasis. An examination of the urine for the Bence-Jones body should be made, especially in case of a myelogenous tumor.

The *treatment* of cranial sarcomata offers no brilliant prospect of cure. Delays are so apt to occur, from the insidious onset of the malady, from the difficulties of diagnosis, from the usual prolonged antiluetic treatment, and from the general tendency in painless growths for doctor and patient to procrastinate, that the operable stage has usually passed when surgical measures are finally courted. It is probable that an early primary growth of the vault may be successfully extirpated in a large number of cases by the circular removal of a wide area of bone enclosing the tumor, whether it be of myelogenous or periosteal origin. It is rare that such an opportunity presents itself, and most of the operative attempts have been made in cases in which recurrence was practically assured. At best these operations are critical and bloody ones.

Bloodgood's studies of the material from Halsted's clinic have shown that, with the exception of the myelogenous sarcomata, operation for this form of neoplasm on the extremities, except as a palliative measure, is practically futile, for, even with early amputation, death from internal metastasis in from one to three years is almost inevitable. In the myelogenous tumors, on the other hand, a local operation is as likely to cure as is an extensive removal. The same thing probably holds true for the cranium.

Carcinoma of the skull occurs only as a metastatic process or by direct invasion from the scalp. Certain cancers of the breast, prostate, etc., seem to be particularly disposed to give metastases to the cranium and spine. The former may be multiple and may reach a large size (Fig. 31). Their appearance and method of growth is similar to the medullary sarcomata; their prognosis is hopeless.

In **myeloma** (Kahler's disease) we have to do with a tumor-forming disease of the marrow, which leads to absorption of the bone, to pathological fractures, and finally, as the process is a multiple one, to painful and incapacitating deformities. This disease, which in the present

state of our knowledge is absolutely incurable, is definitely recognizable by the presence in the urine of an albuminous body known under the name of its discoverer, Bence-Jones. The cranial vault may become involved in this disease, and as the albumosuria, so far as is known, precedes the presence of any visible bone tumors, a certain diagnosis can thus be made. Such a tumor, in the absence of other skeletal evidences of growth, might be mistaken for a medullary sarcoma. Its

FIG. 31.—ULCERATING METASTATIC CARCINOMA OF THE FRONTAL BONE. (Johns Hopkins Hospital.)

removal would be futile, as it is merely the local expression of a general disease.

Chloroma is a rare form of growth, occurring in young people and associated with leukemia. The tumors are due to hyperplasia of the bone marrow and are especially common in the bones of the cranium or face. They have a rapid growth and metastase like most malignant sarcomata. The tumors on section have a greenish color, the source of which is unknown.

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INJURIES OF THE CRANIAL BONES.

"The reason for applying the trepan springs from the nature of the mischief which the parts within the cranium have sustained, and not from the accidental division of the bone."—PERCIVAL POTT.

"Il y a probablement indication de trépaner toutes les fois qu' on doute qu' il y a lieu de le faire."—LEGOUEST.

"La nécessité du trépan me parait une longue et déplorable erreur."—MALGAIGNE.

Injuries of the skull are commonly divided into those which are characterized by a local wound alone, whether contused, incised, punctured, or gunshot, and those which are accompanied by a fracture. This seems like a distinction without a difference, since a fracture can hardly occur without evidence of a local wound, contused or otherwise; and, on the other hand, it is the exception rather than the rule for an incision, a puncture, or a bullet wound to fail to produce a certain amount of splintering of the bone. Nevertheless, lines of fracture and local comminution need not accompany these wounds, for even a missile like a bullet may enter and emerge from the skull and leave as clean-cut openings as would be made with a trephine; and a flap of bone may be elevated by a blow with a heavy, sharp-edged weapon just as in an operative wound an osteoplastic flap may be purposely raised for intracranial exploration without there being any injury of the bone beyond the confines of the accidental or of the intentional incision. In this respect there may be some reason for our adherence to the time-honored classification.

Cranial injuries in themselves are of less consequence than corresponding skeletal lesions elsewhere. Fragments are not subject to displacement from the pull of attached muscles; defects due to the loss of bone are not crippling; enforced bodily quiet is not demanded. Their seriousness lies in the associated lesions of the brain, which rarely escapes some degree of injury; hence it is the complications on the part of the nervous system which attend injury or fracture of the skull, rather than the cranial lesions themselves, which are of prime moment. These complications are multitudinous and will subsequently be considered.

Wounds of the Skull.—Contusions usually pass unobserved unless a complicating injury has occasioned death, when they may be disclosed at autopsy. A bruise of the bone, whether from a fall, a blow, or a spent bullet, may lead to an effusion of blood under the pericranium or in the bone substance itself, producing an ecchymotic area which proves less resistant to incision with the saw or trephine. It is necessarily associated with an overlying contusion of soft parts, but the vascularity of the strictures is such that nutritional disturbances rarely occur, and an uncomplicated contusion should run its course without symptoms.

The chief danger of these lesions lies in their susceptibility to infection, for, owing to the diminished bacterial resistance of such an area,

a local osteomyelitis may ensue, as has been described. The specimens of so-called contusion which are to be found in our museums, showing an area of softened bone or a shell of the outer table separating by a process of demarcation from the surrounding intact skull, are probably an evidence of infection superimposed on a contusion (Fig. 32).

Simple contusions which have led to no immediate symptoms may stimulate the pericranial osteoblasts into activity, so that local thickening of the bone in the form of flat hyperostoses may appear. These irregular prominences may again reabsorb or, on the other hand, may develop into permanent exostoses of the outer or inner table and may lead to symptoms demanding an operation, especially when the projection takes place from the dural side. It is not uncommon, after a supposedly simple and uncomplicated contused wound, for insidious mental changes to appear, especially in old people; and in the young it is not at all uncommon for epileptiform seizures to date back to such

FIG. 32.—MACERATED SKULL SHOWING SO-CALLED AREA OF CONTUSION (light area) AT POLE OF IMPACT.
Due probably to early stage of infection; note meridional fissure. (Surgeon General's Museum.)

an injury. This is attributable in all probability to an accompanying extravasation of blood, however small, upon or within the cortex, the organization of which starts up a process of fibrosis, which, in the aged, may greatly modify the histological character of a large surface of the brain and resemble the changes of incipient paralytic dementia.

The immediate treatment is purely symptomatic, for unless the contused bone be complicated by an open scalp wound, by osteomyelitis or intracranial symptoms, its presence can only be conjectured.

Incised wounds of the skull are more commonly wounds of intent than accident, and are often produced by saber cuts in warfare or in civil life through attacks of a homicidal nature, with heavy, sharp-edged weapons. They may be unaccompanied by fracture in its true sense, and the incision in the bone may remain limited to the line of impact of the weapon. They may be "penetrating" or "non-penetrating," depending upon whether the weapon has entered the cranial chamber or has been stopped by its walls. They need not necessarily be asso-

ciated with cerebral symptoms unless the wound actually penetrates, for the blow is apt to be a glancing one and the injury confined to a superficial cut of the outer table; it may even slice off a circular shell of bone of greater or less depth, leaving it attached by a pedicle of soft parts. A single blow of this kind, with incision, may not even stun the patient. I have known a man to walk into the hospital after receiving such an injury from a sharp hatchet, he having turned and knocked down his assailant and held him until help arrived.

A non-penetrating wound may lead to concussion or contusion or even extensive intracranial hemorrhage, due to the jar of the blow alone; a penetrating wound is not only liable to these complications, but to others, especially to infection, since septic material may be carried in

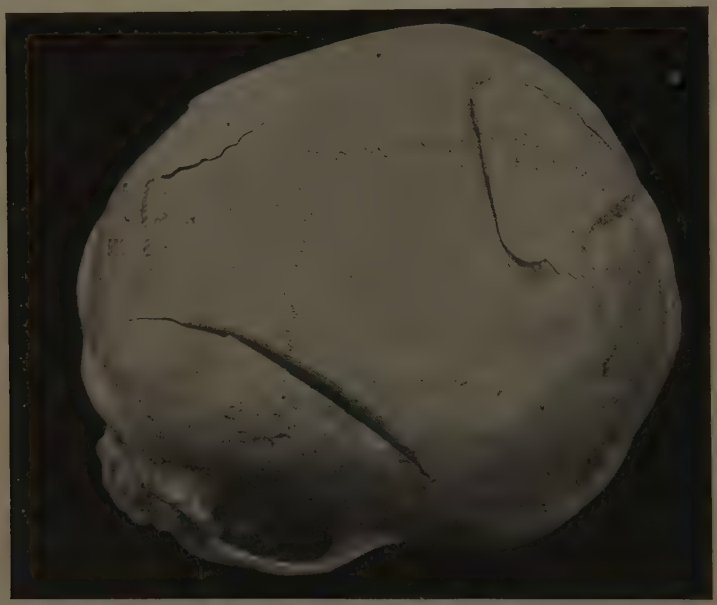

FIG. 33.—MULTIPLE SABRE CUTS WITH AND WITHOUT ASSOCIATED LINEAR FRACTURES. (Surgeon General's Museum.)

through the cleft in the bone. It has been said that incised wounds may occur without accompanying fracture, but in case they are made by wedge-shaped cutting weapons lines of fracture may be expected to radiate from the ends of the incision (Fig. 33). These "splitting fractures" tend to snap together on removal of the weapon. When incised wounds have penetrated we may expect to find some splintering of the inner table with a depression of fragments, for mechanical reasons to be given later on.

The prognosis of these wounds, especially when non-penetrating, is good. They are open from the start and if treated antiseptically their mortality, even in warfare, is not high, especially when brought into contrast with bullet wounds. It should be an invariable rule to trephine and drain all penetrating wounds.

Punctured wounds are produced by pointed weapons and they again are usually wounds of intent. The knife, foil, dagger, bayonet, arrow, or similar weapon which inflicts them is more apt to be directed against a part of the body where the weapon is less likely to be deflected; hence cranial injuries of this character are comparatively rare. They are of serious import only when penetrating, and as such they are more likely to occur at the base of the skull, through the orbits or nose, or in other situations where the skull is thin, as in the temporal region or at the occipital base.

The point of a weapon entering by such an approach will be steadied by the external soft parts and thus may penetrate without glancing; this is especially true of orbital wounds from duelling swords, even from sharp sticks, etc. On the vertex, however, especially in the adult, a heavy blow and one administered perpendicularly is necessary for penetration. When so directed even a thin-bladed weapon may penetrate, and, what is more important, may become wedged in its wound of entrance and be broken off in the effort of extraction.

Fig. 34.—Simple Penetrating Wound of Adult Cranial Vault, without Fracture; made by Knife Blade. (Warren Museum.)

The lesion made by these punctured wounds—even over the vertex where the skull is thick, has a well-developed diploë and a distinct inner table—may be nothing more than a clean-cut incision with no splintering whatsoever (Fig. 34). Such a wound was present in the skull figured on page 211, illustrating a subcortical hemorrhage which resulted from a puncture made with an ordinary pocket-knife.

The serious nature of these wounds lies not only in the possibility of such an intracranial bleeding, but in the extreme likelihood of an infectious meningitis or cerebral abscess following the inoculation of septic material. Were it not for this there would be but little more risk from such injuries, provided that a meningeal artery, the longitudinal sinus, or one of the important cerebral veins or arteries has escaped injury, than attends the exploratory punctures of the ventricle—an operative procedure which represents, when made with a drill, a typical punctured wound of the skull.

Owing to septic complications a punctured cranial wound has long been accredited with especial danger, and it is one of the few forms of cranial injury concerning the treatment of which there is common agreement. If the case presents itself early it is wise, after making the usual preparation for any cranial operation, namely, shaving and disinfection of the scalp, to enlarge the wound by linear incision. A

button of bone which includes the puncture should then be removed with a large trephine, in order to disclose chance fragments of displaced bone from the inner table or the broken point of the weapon. If there is evidence on exposing the dura of a cortical hemorrhage it may be wise either to enlarge the opening or to turn down a large osteoplastic bone flap with the original trephine opening at its center. In this way alone can a clear view be had of the intracranial conditions. Only in case the puncture lies over the neighborhood of the longitudinal sinus is it impossible to furnish such a generous area of exposure; a sinus injury can only be packed in order to control hemorrhage. If there exists any doubt whatever as to the cleanliness of the wound a drain must be left from the cortical lesion through the open meninges and original trephine opening and the wound allowed to close by granulation. There are oft-repeated tales of untreated penetrating wounds in which a weapon like a knife-blade or point of a foil has been broken off and has remained for years in place, penetrating the bone, meninges, and brain without giving serious symptoms.

FRACTURES OF THE SKULL.

Terminology.—The skull may be said to be fractured in distinction to its being wounded when, as the result of a blow, it becomes cracked or broken into more or less separate pieces. These injuries are classified in a variety of ways:

(*a*) According to the mechanism of their production.

(*b*) According to the presence or absence of a communicating wound.

(*c*) According to the form assumed by the fragments.

(*d*) According to their situation.

(*a*) Depending on the mechanical factors at work in their production, they are distinguished as (1) *bursting fractures* and (2) fractures due to local depression or indentation—so-called *bending fractures*. In the case of fractures the result of penetration by modern high-velocity projectiles a further mechanical element comes into play, producing *expansion fractures* through the explosive force of hydrodynamic action.

(*b*) Fractures are *open* or *compound* when they are exposed by a wound of the overlying soft parts; they are *simple* or *closed* when the soft tissues covering them remain intact.

(*c*) According to their form they are distinguished: as *linear* or *fissured* fractures when the bone is merely cracked without displacement; as a fracture by *diastasis* when there is a simple separation of the sutures; as *comminuted* or *fragmented* fractures when the lines of fracture intersect, so as to isolate separate particles of bone; as *depressed* fractures when fragments of bone, whether of the entire cranial thickness or of the inner table alone, are driven below their spherical level; as *perforating fractures* or *fractures with loss of substance* when they are the result of punctured wounds or when the fragments at the seat of the penetration have been carried away, leaving a defect, as is the case in most penetrating bullet wounds. And of these chief varieties many subdivisions may be made.

(*d*) Lastly, depending roughly on their anatomical situation, they are distinguished as *fractures of the base* and *fractures of the vault*, and although the two are often combined they may exist separately and have different characters. Thus, fractures of the base are usually linear and their fragments, if comminuted, are rarely displaced, for the base is much less accessible to direct injury; hence, fractures there are usually the indistinct result of violence applied elsewhere. On the other hand, the vault is directly exposed to injury and local comminution with dislocation of fragments is common, and as the bone is thick and has two determinable layers there are special influences which modify the character of the fragmentation.

(*a*) **The Mechanism of Fractures.—Bending, Bursting, and Expansile Fractures.**—Regarded as a hollow shell of bone which possesses elasticity sufficient to rebound when dropped, the cranium must needs differ from all other bones of the skeleton in the mechanism of its injuries. Certain of the physical laws which explain the peculiar form assumed by these injuries are known to us; others are still in dispute, and though, from a strictly clinical point of view, of chief importance is the knowledge that under certain conditions breaks occur in a certain manner and lead to certain complications, we naturally search for an explanation of the reason why they so occur, even though this information may in no wise affect our diagnosis, prognosis, or treatment.

Teevan, Wahl, Rauber, Félizet, Aran, Bohl, Bruns, Bergmann, Kocher, and a host of others have undertaken clinical and experimental investigations directed toward the elucidation of the underlying principles governing cranial fractures.

We must take into consideration the double effect of an impact, for the blow may produce (1) disturbances which are direct and chiefly of local consequence, and (2) those which are indirect and lead to solutions of continuity at a distance. Setting aside for the moment its irregularities and considering the skull to be an elastic globe, an impact will momentarily lessen its diameter in line of the blow, and force nearer together the point or pole of impact and the point on the sphere diametrically opposite. As the impact forces the poles together it will at the same time bulge out the sides of the sphere and thus increase the equatorial circumference and, in a lesser degree, the circumference of all the other circular planes which lie perpendicular to the polar diameter. If the distortion following the impact is inconsiderable the skull, owing to the elastic rebound, will resume its former shape unimpaired. If the distortion, on the other hand, is so great as to overcome the molecular cohesion of the bony particles, they will be disrupted. This may take place (1) as a rupture or bursting of the bone in parts remote from the poles of impact where cranial dimensions have been increased to the point of overcoming tensile strength of the particles, and (2) as a local indentation at the pole of impact where cranial dimensions have been diminished to the point of overcoming the local resistance of the particles to pressure. These two qualities of elasticity—tensile strength

and resistance to pressure—have been the objects of special study by Rauber, who has shown that resistance to pressure is a third greater than tensile strength. This, however, does not mean that fractures are less likely to occur at the pole of impact than at a distance, for other factors come into play.

Before going further, specific examples of the direct and the indirect effects of an impact may be given to illustrate the difference between the bending and the bursting fractures of von Wahl.

In a drunken brawl a laboring man was struck on the forehead by the corner of a heavy bottle used as a club. There resulted a local indentation with a round, cup-shaped depression about 8 cm. in diameter. Here was a typical bending fracture, the injury having been restricted to a comminution of the area immediately surrounding the pole of impact, due to overcoming the resistance to pressure without any radiating lines of fracture (tensile bursting).

On the other hand, a shipwrecked sailor's head was caught between the flat surfaces of the side of a vessel upon which he was working and a heavy swinging beam. The poles of impact, as represented by the bruises subsequently found, were practically over the parietal eminences. There was no local injury to the bone at these poles, but a single linear fracture connected them by running across both temporal bones and into the middle fossæ of the base of the skull. Here we have a typical bursting fracture, the bony injury having taken place at a distance from the poles of impact, due to the overcoming of the tensile strength or cohesion of the particles at the base in consequence of the increased equatorial diameters. As is usually the case, the fracture had occurred in the direction of a meridian connecting the poles and in the line of that particular meridian which passes through the weakest part of the skull, namely, at the base where cohesion is most easily overcome.

Local Character of Injuries through Bending.—These fractures usually result from the sharp impact of a body with a comparatively small surface. Such a blow expends its force quickly and a rebound occurs before the form of the skull as a whole has been sufficiently altered to produce lesions at a distance. At the pole of impact the bone is broken and the displaced fragments do not resume their former position (Fig. 35).

In spite of its greater thickness and vaulted construction fractures of this sort are more common on the exposed calvarium than at the inaccessible base. The character of the lesion, furthermore, is influenced by the structural peculiarity of the bone: namely, its two dense tables separated by a spongy diploë. Owing to this, an indentation which leads to a bending fracture will cause the inner table to splinter and give way before the outer. In consequence we not infrequently find fractures limited to the inner table—a circumstance known even to the earliest writers in medicine, who explained the phenomenon on the supposition that the inner table was more fragile or brittle than the outer one: hence the "vitreous" surface. Not until Teevan's studies was the process satisfactorily explained on the ground of tensile strength or cohesion of particles on the one hand and of resistance to pressure on the other. There is no simpler illustration than the oft-used one of

a green stick broken across the knee. The cranial impact leads to a local indentation, which tends to pull apart the particles comprising the inner table and to drive together those of the outer (Fig. 36). In certain rare cases the process may be reversed and the outer table alone

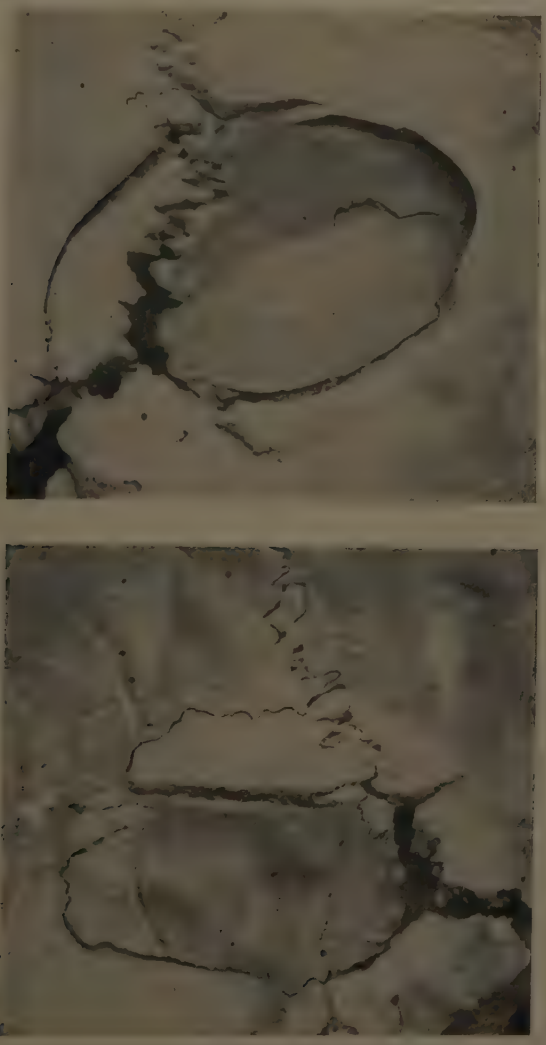

FIG. 35.—OUTER AND INNER CRANIAL SURFACES, SHOWING FIXED INDENTATION FROM BENDING FRACTURE OF THE VAULT, INVOLVING BOTH TABLES.

Note general circular outline with single radial fracture by diastasis—compare with (D) Fig. 36. (Surgeon General's Museum.)

suffer; this implies a blow from within. Both Teevan and Bergmann have given instances of such lesions; thus, after traversing the cranial cavity, a spent bullet may strike the inner surface of the skull and fracture the overlying outer table alone.

If the force of the blow has been expended by the time the inner table gives way, it alone suffers fracture; if it continues, the outer gives way as well, but in the latter case it is always to be borne in mind that the inner table splinters over a wider area than the outer. A lesion which is limited to the inner table alone can only occur in a skull well provided with diploë, and consequently in infancy and old age the bone will usually give way throughout its entire thickness at the same moment.

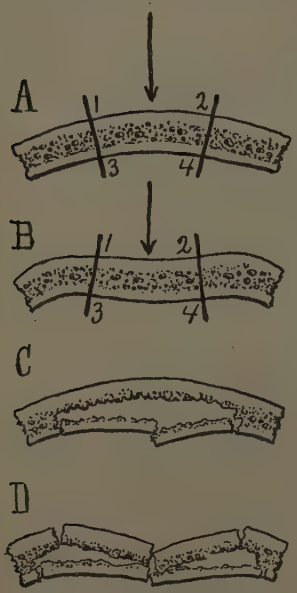

FIG. 36.—ILLUSTRATING MECHANICAL PRINCIPLE OF BENDING FRACTURES.

A and B, Arrow shows direction of impact [3 and 4 are dragged apart until tensile strength is overcome; 1 and 2 are crowded together until resistance to pressure is overcome (Teevan)]. C, showing possible effect on inner table alone; D, showing possible effect on both tables.

These bending fractures may be associated with little or no displacement of fragments; they may, on the other hand, lead to a marked depression whose floor is made up of firmly wedged fragments from the two tables. They, furthermore, are usually bounded by an irregular circular fissure, into which lines of fracture radiate from the central point of impact. An excellent example of such a circular fracture from bending occurs among the comparatively rare instances of this form of fracture at the base, when, as the result of a fall upon the buttock the impact is transmitted to the occipital bone through the spinal column, and the circular fracture more or less clearly surrounds the foramen magnum.

Distant Effects of Injuries through Bursting.—A diffuse blow from a flat surface is prone to cause effects at a distance, just as a concentrated one from a small body is apt to produce local effects. A bursting fracture of typical form, comparable to the lesions which von Bruns has produced experimentally by compressing skulls in a vice to the point of fracture, was cited in the clinical note given above, but it is unusual for the head to be caught and squeezed in this way. An analogous injury may occur when, lying on a hard surface, it is struck by a falling body, though a violent blow against one side of the cranium alone—the head itself usually being the moving force—is the more common method. Though the striking surface, favorable for a bursting effect, should be a flat one, it is common enough for some forms of impact, which produce primarily an indentation, to cause a bursting of the skull as well, in case there is no immediate rebound and if the force exerted be sufficient. Thus, we often find meridional fissures which radiate from a local bending fracture (Figs. 35, 37, 46) situated

at the pole of impact or, indeed, even in the absence of a polar fracture (Fig. 32).

Thus, most fissured fractures are an expression of the indirect or bursting effect of a blow, and inasmuch as the base of the skull is more fragile than the vault these fissures occur most readily in this region

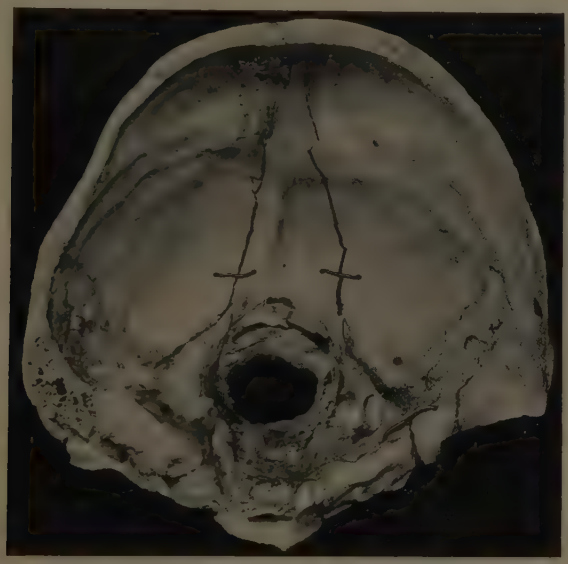

FIG. 37.—FISSURED FRACTURES AT THE OCCIPITAL BASE FROM BURSTING, NOT INVOLVING FORAMEN MAGNUM. (Warren Museum.)

(Figs. 37 and 38). Having oftentimes no apparent connection with any lesion at the point of impact they naturally are spoken of as the indirect result of violence.

The view that these injuries at a distance are due to the effects of a counter-injury or *contrecoup*—a term introduced by French surgeons in the latter half of the eighteenth century—is one which remains popular, though it has been shown to be mechanically wrong. Molecular oscillations, set up at the pole of impact, were supposed to traverse the skull in meridional directions and, concentrating at the opposite pole, to lead, through vibration, to a local lesion there, even though the force may have been insufficient to produce a fracture at the point where the injury was received. As fractures could not be produced experimentally in this way, Aran propounded a *theory of irradiation:* this in turn has been modified, since the observations of von Bruns on the elastic properties of the skull, by that which accredits these distant injuries to rupture consequent upon a change of form, a view which has received the support of the more recent studies of Messner, Hermann and others, more especially of von Wahl. By them it has been shown that the line of the fissure takes a direction parallel to the polar diameter and tends consequently to follow one of the meridians of the sphere. Other things being equal, the fissures would doubtless begin in the equatorial zone of one of these meridians and follow the line of least cohesive resistance toward the pole of impact. Inasmuch, however,

as one hemisphere (the base) of this cranial spheroid is the weaker, no matter in what direction the polar diameter of the impact lies, the portion of the meridian which passes through the base will be the one first to give way, whether it happen to be near the pole or near the equator. Thus, either a blow directly upon the vertex of the skull, a lateral squeeze, or a unilateral blow might cause a bursting fracture with a basal fissure which occupies precisely the same situation. Most of these meridional fissures from bursting tend to cross the basal fossæ, anterior, middle, or posterior, in a transverse direction, though longitudinal cracks are occasionally found, particularly when the polar diameter of impact happens to connect the brow and occiput. It must be borne in mind too that the fissures need not be single, but there may be several meridional lines of radiation, and this is particularly apt to be the case when they radiate from a bending fracture and are not simply the result of bursting alone.

Not only the base, but the vault as well, has certain areas of structural weakness, in which these fissures will naturally occur. As pointed out by Hilton, there are certain so-called buttresses which serve as supporting arches; an anteroposterior arch from glabella to occipital protuberance and two transverse arches. The anterior of these has its base upon the external angular processes and passes up through the frontal eminences to the mid-line; the posterior rests upon the basilar processes and arches through the parietal eminences to the mid-line. Each of these arches is continued into certain areas of the base itself, which are relatively stronger than others; the anteroposterior into the body of the ethmoid, sphenoid, and basilar process; the transverse frontal into the wings of the sphenoid; the transverse parietal into the petrous bones. Between these buttresses the bones are relatively thin and this is particularly true of the space between the frontal and the parietal arches, where lines of fracture which pass down into the middle fossæ at the base are especially apt to be found.

Thus, whether they involve the base or vault, bursting fractures are theoretically liable to occur in the interspaces between these arches and their basal continuations. On this theory of structural weakness alone it can be understood that lines of bursting fracture may be deflected, from the meridional plane which they theoretically should follow, into other channels. It is Félizet's view that they pass downward between the buttresses of Hilton to the nearest basal fossa. This may explain the results of Aran's investigations; namely, that there is a definite relation between the seat of impact and the resulting basal fracture and that fractures reach the base by the shortest anatomical route rather than in a meridional direction. Thus, a blow upon the occiput may lead to a basal lesion in the posterior fossa rather than by one situated at the counterpole of the skull.

We learn from these observations that bursting fractures need not be associated with any displacement of bone, but that linear cracks occur which have a tendency to run into the nearest weak portion of the cranial base. These cracks or fissures enter the middle cranial fossæ more often than the anterior or posterior, and it is Walton's view that they often seek out the sella turcica, which presumably is the weakest point of all (Fig. 38).

There are factors other than those already mentioned which are thought to modify the direction of these cracks from bursting. Among them are the foramina and the sutures. Whether the fractures tend to seek or to avoid the basal foramina is a matter of dispute. It seems to depend upon the relative strength of the rim of the foramen and the neighboring bone. When the rim is thickened and strong, even so large

a defect as the foramen magnum need not be an evidence of local weakness (Fig. 37); no more need a trephine opening in the vault in any way weaken the elastic strength of the cranial sphere. Nevertheless, there are certain foramina which are apt to be involved, as the posterior lacerated space, the foramen ovale, and the facial and acoustic foramina.

The sutures, on the other hand, often serve to deflect fissures from the direction which they should have taken by mechanical laws. This is especially true for the skulls of young individuals. (See Fractures by Diastasis.)

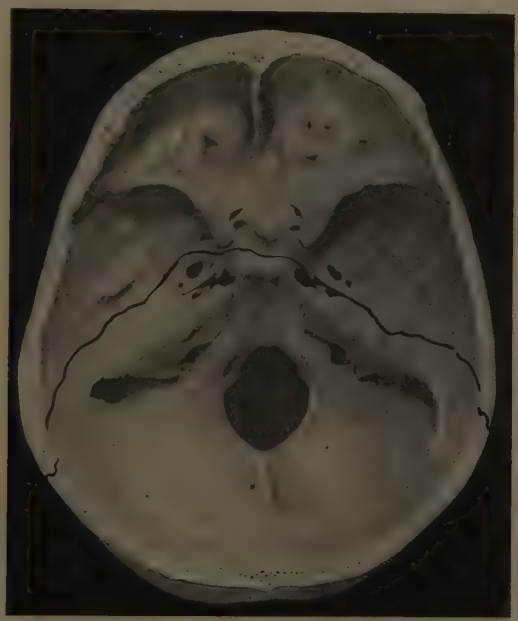

FIG. 38.—BASE OF SKULL SHOWING TYPICAL BURSTING FRACTURE PASSING THROUGH MIDDLE FOSSÆ AND SELLA TURCICA.

The Explosive Effect of Hydrodynamic Force.—The introduction of the modern firearm, with its peculiar non-deforming, hard-mantled projectile, has brought an entirely new element into the mechanism of penetrating gunshot wounds, particularly those involving the cranium. It has been made the subject of special study by Kocher, von Bruns, Coler, and Schjerning. When such a projectile, with its extreme initial velocity and great penetrating power, traverses the incompressible semifluid brain, enclosed as it is within a solid covering, it exerts an enormous explosive (hydrodynamic) force against the inner cranial surface. Were the cranial chamber empty a simple penetrating wound of entrance and exit would result, but being full the tremendous force is transmitted against all points of its inner surface and consequently its walls become shattered into fragments.

(*b*) **Clinical Varieties of Fracture.** — By the qualification *simple* or *compound* or, possibly better, *open* or *closed*, we indicate, as in

skeletal lesions elsewhere, that the fracture is covered by intact soft parts or communicates with the air through an external wound. The distinction is possibly of less vital significance than formerly and, indeed, here more often than in any other part of the body we deliberately, by operative explorations, turn simple fractures into open ones for the replacement of dislocated fragments or to avoid other complications. In compound fractures of the base, however, we are almost as helpless in the prevention of infection as were our predecessors; for when these injuries communicate with the ear, the pharynx or the sinuses accessory to the nasal cavity, where pathogenic organisms lurk, a doorway which we cannot reach is opened to infection. A compound fracture of the base from other cause than bursting is unusual, though it may occur when a weapon, a bullet, or other missile has entered the skull from below. In such a case careful surgical cleansing and drainage is demanded.

Fractures According to Their Form.—Fissured or linear fractures, as we have seen, are the usual result of bursting; they tend to take a meridional course, radiating from the pole of impact, and, further, owing to its structural weakness, they more commonly occur at the base. When the skull resumes its former shape, after the moment of deformation which causes the bones to spring apart, the fissure will close tightly, provided there has been no associated fragmentation. At the moment of separation of a fissure, substances like hair, portions of headgear, or pieces of the missile which inflicted the blow may either be introduced wholly into the cranial chamber or be caught in a vice-like grip when the edges again snap together. It acts like the "meridional" crack in a child's hollow rubber ball, which gapes when its poles are compressed.

A fissured fracture may occur as a single linear crack (Fig. 32); it may fork or branch (Fig. 44), or there may be multiple fissures radiating from the point of impact (Fig. 46). A simple linear fissure may close so snugly as to be difficult of detection even on direct exposure. Attention may be called to it, however, by the extrusion, along the closely approximated edges, of fine drops of blood. After death this does not help and at autopsy fissures may escape other than the closest scrutiny. In other instances, whether from interposition of tissue or from some dislocation of fragments, an extensive meridional crack may continue to gape. Such a condition, especially when the fissure has included the vault, may be detected by percussion, or when the head has been shaved, by auscultation combined with percussion, the blow eliciting a "hollow-cask" sound. Furthermore, there will be tenderness along the line of fracture, though this is of little aid in unconscious patients. It is to be remembered that sutures are often mistaken for fissures.

Linear fractures, though simple in themselves, are especially prone to be accompanied by intracranial complications, for their very presence indicates a diffuse blow the effect of which is usually widespread. Hence, cerebral contusions are common. The fissures often run across the

meningeal grooves and lead to extradural extravasations (Fig. 98, p. 187), and more or less subdural hemorrhage is the rule in the linear fractures of the base.

The treatment, therefore, resolves itself into the treatment of the complications rather than of the fracture—viz., the evacuation of the clot in an extradural hemorrhage; the drainage of the cerebrospinal space if subdural hemorrhage or edema has been sufficient to cause bulbar symptoms.

Fractures by Diastasis.—Linear fractures may be deflected into one of the sutures (Fig. 39), due to the fact that, before the complete obliteration which they may undergo late in life, they offer less resistance

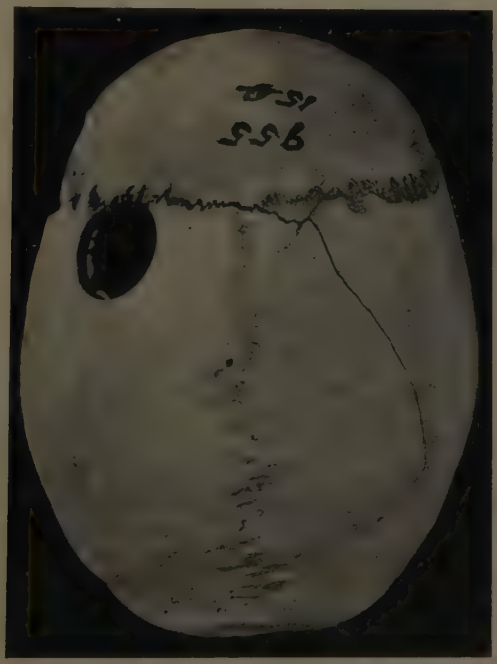

FIG. 39.—FRACTURE BY DIASTASIS SHOWING LINEAR FISSURE DEFLECTED INTO THE CORONAL SUTURE. (Warren Museum.)

to the cranial deformation than does the bone elsewhere. In the young the lesion may occur as a true separation of the bones. I have seen at operation upon a child of twelve, whose head some days before had been caught and laterally squeezed, a simple diastasis of the coronal suture, which had torn the dura, leading to the escape of cerebrospinal fluid under the scalp (spurious meningocele); at no time had there been any cerebral symptoms. In the adult, on the other hand, the process is necessarily more than a simple diastasis, for union is so firm, owing to the close dovetailing of the irregular bony margins, that separation of the sutures cannot occur otherwise than by a break.

Comminuted fractures are those characterized by more or less

fragmentation or splintering. The comminution may be confined to the area of impact or the entire cranium may be broken into pieces. Being a common result of local deformation or inbending at the point of injury, they are usually situated on the vault and depend for their production on the character not only of the blow (a sharp one with quick rebound), but also of the striking body.

From the standpoint of the bony lesion itself they are more serious than linear fractures, owing to the usual displacement of fragments—**fractures with depression**. This in its simple form is schematically shown in Fig. 36. Extensive comminution, however, may occur with little, if any, dislocation of the broken pieces (Fig. 44). We may, furthermore, in the elastic skulls of infants have depression with no comminution or, indeed, with a total absence of fracture. Finally, in certain rare cases fracture may occur with actual elevation of a fragment

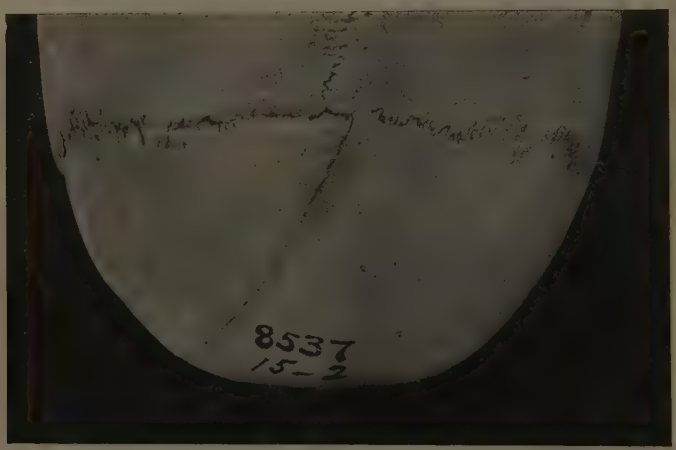

FIG. 40.—SKULL SHOWING HEALED ANGULAR FRACTURE OF FRONTAL BONE (LINEAR AND BY DIASTASIS) WITH ELEVATION OF FRAGMENT. (Warren Museum.)

(Fig. 40). These effects, however, are unusual; comminution and depression commonly go hand in hand. Hence they will be considered together.

The comminution and depression may affect the inner table alone (Fig. 41) or both tables, in which case the fragments may consist of the entire thickness of the skull or, in diploëtic skulls, of the separated tables. When thus separated the fragmentation of the inner is always more widespread than that of the outer. The fragments may form a cup-shaped depression, often termed by English writers "pond fracture" (Fig. 43), or they may become tilted at the periphery and slip under the intact cranial edge. We thus have *peripheral* or *central depressions* (Fig. 42).

From the pole of impact in comminuted fractures there are often numerous radiating or meridional fissures; these in turn are often connected by zonal lines of fracture, like the connecting strands of a spider's

web; and in these cases the farther from the point of impact, the farther apart are the zonal lines, and consequently the larger the fragments. When comminution is the result of diffuse blows, as in the skull of the "butting" negro in the Surgeon-General's Museum, or when it follows falls from a great height, irregular fragmentation, like a broken egg-shell, may occur, with fissures having no definite configuration.

Almost all punctured or penetrating wounds are accompanied by more or less local fragmentation, with depression, which particularly affects the inner table.

Depressed fragments may heal in place and their irregularities become, in the course of time, largely smoothed off (Fig. 43).

FIG. 41.—COMMINUTED AND DEPRESSED FRACTURE LIMITED TO INNER TABLE. (Surgeon General's Museum.)

Perforating fractures are due to cuts, to stab-wounds, to the penetration of sharp tools which have fallen from a height, to the blow of a pick, the thrust of a bayonet, and what not. They are associated with more or less fissuring, with fragmentation and with depression of fragments, especially of those broken from the inner table about the margin of the wound. Their course, diagnosis, complications, and treatment do not differ materially from that of wounds of the skull (p. 63), unassociated with fracturing, though produced by similar agencies. When a portion of bone has been carried away, leaving a defect, they are called *fractures with loss of substance* (Fig. 42).

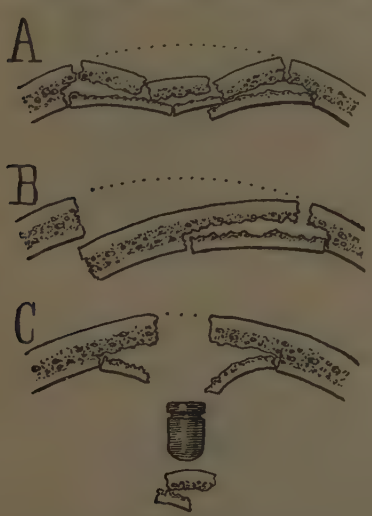

FIG. 42.—DIAGRAM OF (A) COMMINUTED FRACTURE WITH CENTRAL DEPRESSION; (B) ONE WITH PERIPHERAL DEPRESSION; (C) ONE WITH LOSS OF SUBSTANCE.

One particular group of perforating fractures deserves special consideration; namely, those which are the result of wounds from firearms.

Gunshot Fractures.—In their simplest form these are perforating fractures which produce a circular loss of substance. When the result of a wound at short range from the modern small-arm, we have seen

that the skull may be burst outward by the explosive action of hydrodynamic pressure (Fig. 44). We have learned, too, that these are compound or open fractures; that they are almost always comminuted ones with some depression of fragments; and, finally, that they often lead to sepsis, hemorrhage, or other intracranial lesions, which make of them a particularly dangerous and crippling form of injury.

There are, however, other types of gunshot fracture less serious, since they are non-perforating. Thus, the direct impact of a heavy spent ball may fissure or indent the skull without producing more than a bruise of the scalp. Again, a bullet may pass through the scalp and graze the vault in a tangential direction without penetration, or it may furrow the bone, scooping out a gutter in the outer table alone or leaving a defect of the entire cranial thickness. The lateral force

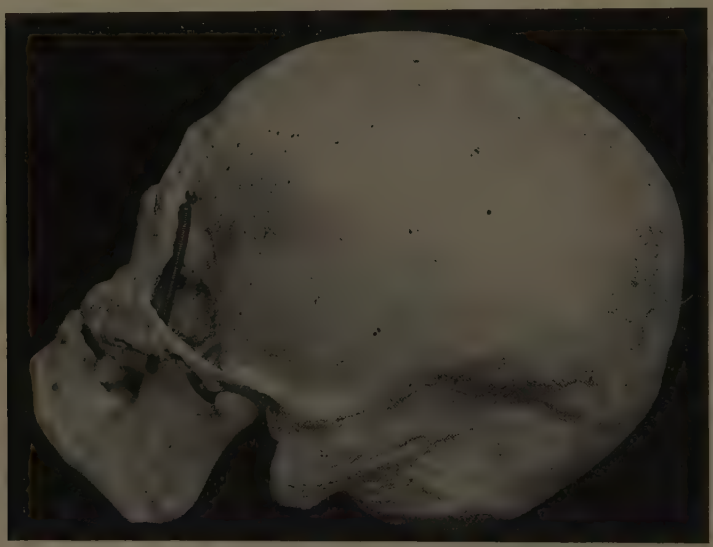

FIG. 43.—SHOWING OLD POND-SHAPED DEPRESSION WITH SOLIDIFICATION AND SMOOTHING OFF OF UNREDUCED FRAGMENTS. (Surgeon General's Museum.)

exerted, during its rapid flight, by the modern high-velocity projectile is sufficient to comminute the skull, even if it be merely grazed, so that only in those localities where the bone is thick and porous or contains air-cells would it be likely to escape considerable local fragmentation from such a tangential wound. For the same reason fractures of the base may occur when a bullet traverses the shell-like bones comprising the under surface of the skull without actually penetrating the cranial chamber; and, further, bullets may become lodged in the thicker parts of the cranial wall and produce more or less local comminution without actually entering the cavity (Fig. 45).

The wound of the bone, as we have seen, may show nothing more than a clean-cut circular or oval loss of substance, but it is the rule for the wounds both of entrance and exit, in case they occur in bones

containing diploë, to show the particular characteristics of punctured fractures; that is, to have a more or less splintered margin, particularly

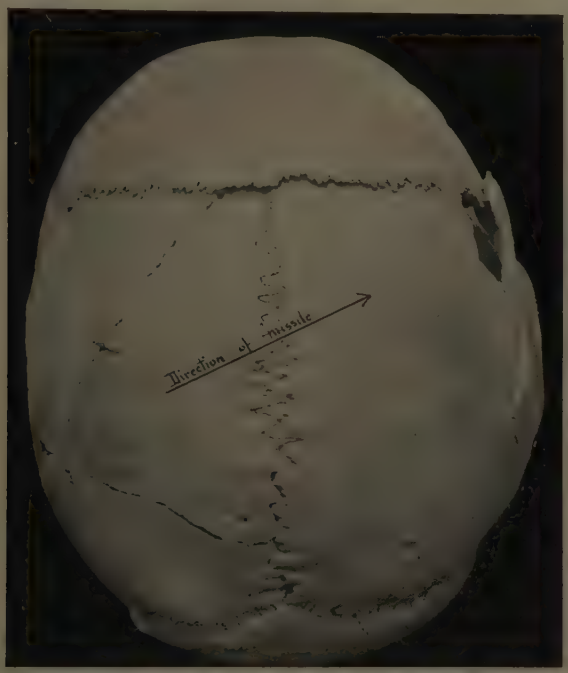

FIG. 44.—SHOWING IRREGULAR FISSURING (ALSO DIASTASIS) FROM EXPLOSIVE EFFECT OF THROUGH-AND-THROUGH GUNSHOT WOUND.
Note meridional cracks radiating from pole of impact. (Surgeon General's Museum.)

of the table which has been last penetrated—the inner table for the wound of entrance, the outer table for that of exit. Hence, when there

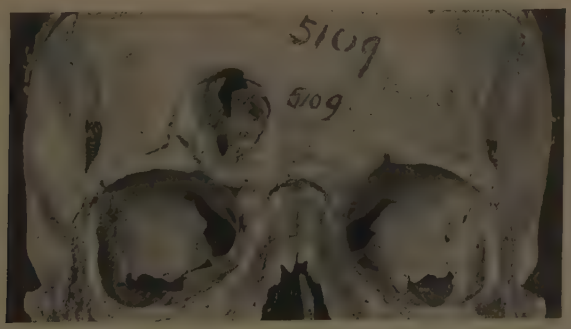

FIG. 45.—SKULL OF INDIVIDUAL WHO DIED FROM MENINGITIS TWENTY-FIVE YEARS AFTER LODGMENT OF BULLET IN REGION OF FRONTAL SINUS LEADING TO PERSISTENT, CHRONIC SUPPURATION. (Warren Museum.)

is a loss of substance due to the actual carrying away of fragments, the circumference of the defect will be greater on the side from which the

missile has emerged, whether it be wound of entrance or exit—a matter often of medicolegal importance. Furthermore, meridional fissures are apt to radiate from the wounds of impact, and these meridians in turn are often joined by circular fissures on zonal planes (Fig. 46).

The damage from perforating bullets depends partly upon the physical properties of the missile and partly upon the speed with which it is traveling. There is great difference, therefore, between the effects of the soft, leaden bullet discharged from a revolver, and that of the

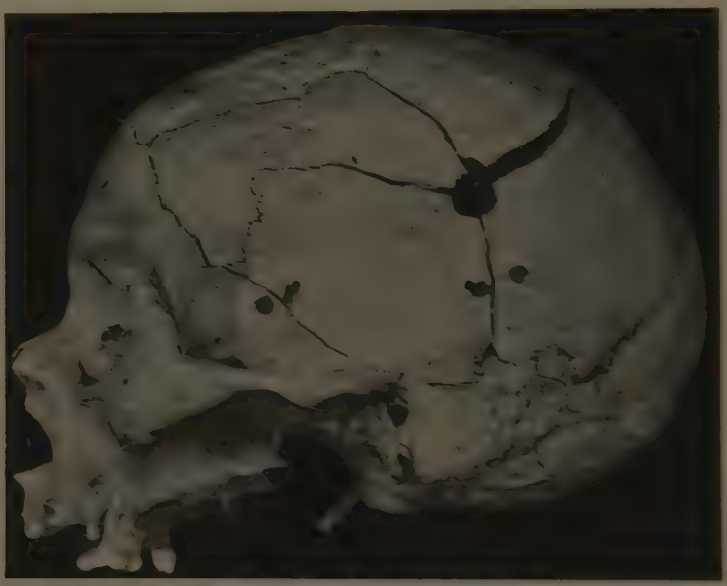

FIG. 46.—[illegible]

Showing 1, Polar wound of [illegible]; 2, [illegible]; 3, [illegible]; 4, [illegible]; 5, zonal fissures encircling the pole. (Warren Museum.)

modern conical projectile with its hard mantle and tremendous initial velocity. The latter missiles, except near the end of their flight, rarely lodge; the former almost invariably do.

In his *Handbuch der Praktischen Chirurgie* Bergmann gave in full the results of experiments conducted by himself and others upon wounds of the head made by the modern rifle. Briefly, it may be said that at close range the skull and scalp are literally torn to pieces and the brain disorganised; that on penetration at 50 yards the scalp remains intact, though the skull is greatly comminuted and brain tissue oozes both from the wound of entrance and exit; at 100 yards there occur zonal fractures which tend to be limited to the area about the wounds of entrance and exit, while meridional fissures radiate from these points, showing that explosive action is still effective; at 1,000 yards the zonal cracks encircling the bullet-holes disappear, and only the radial fissures remain; at the distance of 1 mile the fissures largely disappear, leaving the two clean-cut bullet holes, and not until over 1½ miles does the projectile fail to emerge after entering the skull on one side. All this, of course, is merely relative, for there would be great difference, not only in individual

skulls, but in the position in which they were struck; and it is, after all, a matter chiefly of interest to the military surgeon.

On the whole, these wounds in warfare have a grave prognosis. According to Fischer's statistics from the German army during the Franco-Prussian War, 45 per cent. of 8,132 gunshot injuries resulted in immediate death, and nearly one-half of those found dead on the field of battle had wounds of the skull.

The gunshot fractures which are seen in civil life are more apt to result from revolver shots and in orderly communities to be self-inflicted wounds, whether by accident or intent. Here again the character of the injury depends upon the nature of the weapon and the initial velocity of the projectile. Most of the wounds which one sees to-day are produced by soft bullets fired from the ordinary revolver with no great initial momentum; the heavier army pistols, on the other hand, fire a projectile which at near range has the explosive effect of a rifle. The soft, deforming revolver bullets are apt to lodge either in the bone at the site of entrance or somewhere within the cranial cavity, either at some point in the direct line of their flight or, in case the missile has rebounded, at some point in a line determined by the angle of deflection from the opposite inner surface. At times the course of such a deflected bullet may be mathematically calculated, but to-day the *x*-rays give us a more accurate means for determining its position. It may be said, however, that, as a rule, there is no particular reason for its extraction, for in the absence of immediate complications it becomes encapsulated and, unless the missile chance to lie near the surface, the damage already done will only be increased by meddlesome attempts to locate and extract it.

Fig. 47.—A Not Uncommon Result of a Suicidal Wound in the Temple. Division of Both Optic Nerves, with Blindness.
Sound introduced in track of bullet preparatory to insertion of drain.

The complications which result from penetrating bullet wounds may be classified as *immediate*, or those due to hemorrhage, compression, and destruction of tracts; *intermediate*, or those due to sepsis; and *late symptoms* (irritative and paralytic), giving evidence of the permanent damage done to the cerebral tissues. Hemorrhage, of all the immediate symptoms, is especially to be dreaded, as it may lead to rapid death from compression. In all cases in which there is an increase in intracranial tension from effused blood, the pressure forces the disorganized nervous tissue through the wounds of entrance and exit, and the extruded particles of white tissue are found mingled with the blood which oozes from the opening. It is not uncommon for cranial nerves

to be injured, either by direct section or by implication in a basal fracture.

It is notorious that suicides often fail to accomplish their purpose. Brun has recorded 32 cases, of which number 16 recovered. Of these cases the wound of entrance was in the right temporal region sixteen times, in the left twice, in the forehead nine times, and in the mouth twice. The "temple" is regarded by the laity as a particularly vulnerable spot, which accounts for the preponderance of the attempts in this situation. In them oftentimes the bullet merely passes extracranially from temporal fossa to temporal fossa, through the back of both orbits, cutting the optic nerves and leading to blindness—a sad penalty for a criminal act (Fig. 47). Though unrecorded in Brun's series, suicidal wounds inflicted in the right mastoid region are not uncommon. In the patient shown in Fig. 48 the bullet emerged at the supra-orbital ridge, having crossed in its extracranial course the temporal fossa to the back of the orbit, cutting the optic nerve and fracturing the ethmoid and anterior wall of the frontal sinus. In spite of through-and-through drainage he succumbed in ten days to the intermediate complication of meningitis.

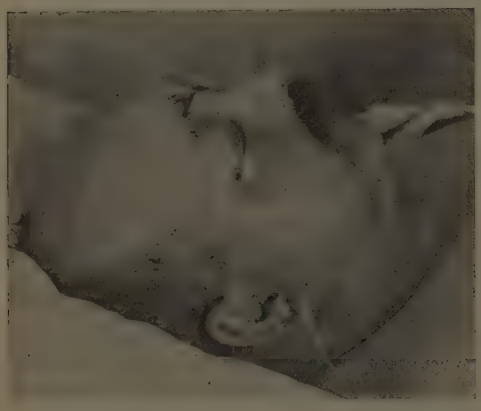

FIG. 48.—PROBE INTRODUCED THROUGH TRACK MADE BY SUICIDAL WOUND ENTERING MASTOID PROCESS.

Though entirely extracranial, death resulted from meningitis secondary to fissuring of ethmoidal plate.

The later complications, in case of "recovery," are paralyses, mental changes, epilepsy, etc. Thus, a patient whose wound of exploration is pictured in Fig. 135, p. 248, was accidentally shot in the mid-line of the forehead at the hair margin. A surgeon removed two pieces of the bullet (supposedly all of it), together with some fragments of bone at the wound of entrance, which finally healed. The patient for a time was aphasic, had a left-sided hemiplegia, and he subsequently developed epilepsy with a peculiar speech aura. An *x*-ray plate then showed a foreign body lodged in the left side of the brain near the skull, and just below the middle of the Sylvian fissure. An operation was performed, adhesions due to an absorbed subdural clot were separated, and a small, dense scar, enclosing the main fragment of the bullet, was removed. This had traversed the left frontal lobe, had struck the side of the skull, and ricocheted into its position. The extraction of the bullet benefited him in no respect and he is progressing to mental degeneracy.

Treatment.—The fracture itself is the least of the ills following cranial gunshot wounds and cannot be considered apart from the other complications. If there is a clean-cut perforation and no serious

immediate symptoms the wound may be left with a simple drain and healing may take place without incident; for unless septic foreign particles have been carried in with the missile, its track quickly cicatrizes and the bullet itself becomes encapsulated. If there is a lacerated scalp and considerable local comminution of the skull it is advisable, after paring the edges of the scalp wound, to enlarge it by incision and to trephine the skull in order to readjust any depressed fragments, to evacuate clots, to relieve tension, and to afford better drainage. A large defect almost always leads to a hernia and perhaps to a fungus cerebri, owing to the swelling of the lacerated brain. Largely owing to this, drainage of the track of the bullet is a most unsatisfactory procedure, and one must usually be satisfied with a superficial drain down to the dura and brain, but not far into the latter. The temptation to probe for, to locate, and to extract deep-lying fragments of the bullet should be resisted by the surgeon; for even if successful in their object these procedures usually serve merely to increase the damage already done by the missile without conferring any benefit whatever from its removal.

The late complications must be met as are those due to cranial injuries from other causes, and here again it must be borne in mind that the paralyses and mental disturbances are not due to the presence of the foreign body, but to the cicatricial changes in the nervous tissue due to its passage through them, and that they consequently are the same whether the bullet has lodged, emerged, or been removed.

Fractures According to Their Situation.—Fractures of the Vault and Fractures of the Base.—There is a certain justification in this common anatomical division, for in the two situations not only do fractures differ in the mechanism of their production, but also in the form which they assume and in the complications to which they are liable. The bones of the exposed vault are more liable to direct, indenting injuries, and hence, despite their greater strength, comminution with dislocation of fragments is frequent; those of the well-protected, though more fragile base, are more subject to fissuring, the result of general deformation of the skull. These, of course, are not invariable rules, for we may have simple fissures of the vault from bursting or a local comminution with depression at the base from bending—an example of which is the not uncommon fracture which occurs about the foramen magnum as the result of falls on the buttock when a direct blow is transmitted to the base through the spinal column. Again, a simple bending fracture of the base may follow a sharp blow on the chin, when the ramus and condyle of the jaw transmit the force to the base—the prize-fighter's fracture. Finally, it is always to be kept in mind that fractures of vault and of base are apt to be associated.

Many statistical studies in regard to cranial fractures have been made from time to time; notable among them is the recent elaborate monograph of Hans Brun, based on 470 cases which in twenty years had been carefully observed in the Cantonal Hospital in Zurich.

Occurrence.—In general it may be said that they are injuries of

young adult life; that they are many times more frequent in men than in women; that in the majority of cases (60 per cent.) they are the result of falls from a height. About one-half of these fractures involve the base, often alone, sometimes with associated fracturing of the vault. On the other hand, it is estimated that 70 to 75 per cent. of all fractures of the vault are accompanied by basal injuries. Fractures of the vault are more often compound than simple, and they occur with about equal frequency in frontal, parietal, and temporal bones, being rare in the occipital region. Basal fractures are more common in the mid-cranial fossæ.

Mortality.—Disregarding the etiological factor, the patient's age, and also the character of the injury, about one-third of all cases in the past have proved fatal, and as the fatalities are largely due to the immediate cerebral complications, modern methods of treatment have not served to greatly alter these figures. The percentage of fatalities increases with age—the younger the individual the more favorable the outcome. Fractures of the base are commonly thought to be attended with a higher mortality than those of the vault, though with our improved diagnostic measures (lumbar puncture, for example) we may find that many cases of simple basal fracture have heretofore been overlooked and regarded merely as concussion—a fact which may make one's percentage of recoveries at least appear larger to-day. Excluding those cases which have died as an immediate result of the injury and those which have later succumbed to infection, the average duration of life in the fatal cases is said to be forty-four hours; so that there is some basis for the old rule, adhered to by Bergmann and Wagner, that survival over two days gives a favorable prognosis.

Of the cases which survive the first forty-eight hours, a considerable number (8 per cent. of all fatalities) die from the intermediate complications of meningitis or abscess. Fractures of the base are more liable to this complication than those of the vault; for the latter are accessible and easily drained, so that, unless there be a defect leading to a fungus cerebri, dangerous from a persisting leak of cerebrospinal fluid, infection rarely occurs. Basal fractures, on the other hand, especially those which open up the sphenoidal or ethmoidal sinuses where pathogenic organisms lurk, are often followed by a meningeal infection. In this case the pneumococcus is the more common agent, whereas in fractures of the vault a streptococcal or staphylococcal infection is the usual one. I have twice seen a rapidly fatal pneumococcal meningitis start up on the third day after what appeared to be a simple, uncomplicated basal fracture with a little bleeding from the nose and so few subjective symptoms that the patients remonstrated at their enforced recumbency.

The *prognosis* is in no way proportionate to the extent of the cranial injury, but depends entirely on the character of the intracranial lesions which will be fully considered anon. An insignificant crack of the base, associated with a focal hemorrhage in pons or medulla, may put a sudden end to life; whereas an extensive fragmentation of the vault,

which allows for considerable cerebral expansion, may actually save life through "decompression." An insignificant punctured fracture which does not even produce concussion may prove fatal from meningitis or abscess later on; a comminuted and depressed compound fracture may, on the one hand, cause death quickly from hemorrhage and compression, or may heal practically untreated and give few symptoms. On the whole the immediate prognosis is more favorable in bending fractures than in bursting fractures; in other words, more favorable in those which are accessible than in those which are not, for it depends largely on the possibility of early treatment not only of the fracture, but of its underlying complications.

The *diagnosis* of fractures of the vault may offer difficulties, particularly in the case of linear fissures and of those involving the inner table alone. One, however, is much more apt to be misled by the peculiar feel of the infiltrated edge of a subaponeurotic extravasation into making a faulty diagnosis than to overlook a cranial fracture when it is actually present. When the scalp is intact, linear fractures may at times be recognized through lines of tenderness on pressure, particularly over the temporal fossa, and by a changed percussion note if there is any gaping of the fissure. In open wounds there should be no difficulty in recognizing even a closely approximated fissure, owing to the blood which oozes from between its edges; sutures, however, may be mistaken for fissures. Localizing cerebral symptoms, to be discussed later, are often helpful in determining the situation of a depression if it is not actually palpable, and involvement of cerebral nerves may indicate the direction taken by a meridional fissure. Old deformities dating from birth, patches of senile atrophy, defects from former diseases, like syphilitic osteomyelitis, and the irregularities present in all skulls, though more marked in some, may at times be mistaken for depression.

In fractures involving the base alone we must, in the long run, depend entirely upon the symptoms which we have learned to recognize as common accompaniments of these injuries, rather than upon any direct evidence of the bony lesion. Evidence from intracranial or extracranial bleeding, either free or into the tissues, is of particular value.

The intracranial extravasations usually take place into the subdural space, for, owing to its close attachment, the dura is usually torn when the bones are fissured. The amount may be small or so extensive as to cause rapidly fatal compression. It may be recognized by finding evenly distributed red blood-corpuscles in the cerebrospinal fluid withdrawn from the lumbar meninges.

The extracranial extravasations may also be free and bleeding may occur from the nose, mouth, or ears, in case the ethmoid, the accessory sinuses, the Eustachian tube, or the tympanic cavity have been implicated. It is necessary to exclude a simple "bloody nose," rupture of the tympanum, or entry of blood from without into the auditory canal. Extravasations into the tissues (ecchymoses) appear more tardily.

They are common in the orbit, under the eyelids or conjunctiva when the frontal plate is injured, and in fractures of the middle or posterior fossæ they find their way to the surface over the mastoid process or down the neck after some days.

The escape of cerebrospinal fluid often occurs with fractures entering the middle fossa, particularly when they involve the petrous bone and when both dura and tympanum have been torn. The escape of bloody fluid may continue for days and the symptom need not always be entirely undesirable, as pressure may be relieved thereby. Open fractures which communicate with the nasal or pharyngeal cavities may likewise be followed by a leakage of cerebrospinal fluid, though it is less common from these situations. In rare cases, after a lesion of the petrous bone unaccompanied by rupture of the tympanic membrane, fluid may escape into the pharynx by way of the Eustachian tube and either be swallowed or flow from one nostril when the head is tilted down.

The *complications* of cranial fractures often serve as an aid in diagnosis. They are estimated to occur in 46 per cent. of fractures of the vault and in 64 per cent. of those of the base. Varying grades of concussion, contusion, or compression are almost inevitable; only exceptional forms of fracture occur without one or another of these classical symptoms, though any one of them may result from an injury in the absence of fracture. They are apt to be more outspoken in basal lesions, owing to the diffuse character of the blow necessary to produce a bursting fracture. As will be described in its proper section, compression may be general or local, and when local it may give cerebral symptoms of irritation or of paralysis, which serve to point out the situation and character of the cranial lesion. This is often the case with indented fractures of the vault which lead to cortical laceration of the brain, or with meridional fissures which cross the meningeal groove and lead to extradural hemorrhages with their characteristic "interval" between symptoms. These extradural hemorrhages can only occur under the vault where the dura is more easily separable from the bone than at the base; and it is to be remembered that they are not necessarily an indication of fracture, but may be the result of simple deformation not sufficient to break an elastic skull.

Involvement of the *cerebral nerves* may prove a valuable diagnostic aid. The facial is by far the most commonly injured, owing to its devious course through the petrous process, so frequently implicated in fissures entering the middle fossa. The mere presence of hemifacial palsy, however, after an injury to the head need not indicate with certainty the peripheral involvement of the nerve, for it may be due to a contralateral central lesion. In order of frequency the abducens comes after the facial, and diplopia from an involvement of any or all of the oculomotor nerves may be the result of breaks in the neighborhood of the sphenoidal fissure. In fissures crossing the frontal fossæ the olfactory often suffers. The optic may be affected by direct injury, and lesions of the trigeminus,

glossopharyngeal, vagus, spinal accessory, and hypoglossal have been recorded. The nerves are apt to be affected in groups, the seventh, eighth, and sixth together; the fifth and third; or the ninth, tenth, and eleventh. The lesions usually occur at or near their foramina of exit, due either to actual laceration or to local compression from effused blood; and hence a study of the paralyses may indicate the fossa which the fracture has entered, whether anterior, middle, or posterior.

Serious complications from hemorrhage may follow *injuries to blood-vessels*, particularly when the sinuses or meningeal artery are lacerated, and occasionally linear fractures crossing the middle fossa toward the pituitary fossa may so traumatize the cavernous sinus and carotid as to produce an arteriovenous aneurysm with pulsating exophthalmos.

The sequels heretofore considered are common to all lesions of the skull; those due to an *infection* are almost without exception limited to open fractures, whether of base or vault. In them purulent cellulitis, osteomyelitis, septic sinus thrombosis, meningitis, or cerebral abscess were formerly almost to be expected. Modern methods have largely lessened these evils in the case of the vault, even if not in basal lesions.

An insignificant fissure which passes across the ethmoid plate may open a pathway of infection from the nasal cavity and lead to a rapidly fatal meningitis. Cerebral abscess is especially common after punctured or gunshot wounds from the deep inoculation of infective agents, though it occurs often enough in compound comminuted fractures which have led merely to a superficial laceration of the cortex.

Rarer complications, like spurious meningocele, pneumatocele, and others too numerous to mention, may likewise occur. Cysts occasionally form after fractures, either from a torn dura, from the partial absorption of a clot in the subdural space, or from a subcortical extravasation. Sugar may appear in the urine (traumatic glycosuria), usually about eight to twelve hours after the injury and in about 9 per cent. of all cases, according to Higgins and Ogden. All of these, as well as the so-called post-traumatic neuroses, result from the cerebral, not from the cranial injury.

The *process of healing* does not take place as in the long bones, where there is an abundant callus formation. Dura and periosteum, however, are both capable of forming new bone, as we have seen in exostoses, osteophytes, etc., and complete repair, even when there has been a loss of substance, may occur. It may, however, be long delayed or completely fail, due, according to Bergmann, to the destruction or loss of the osteoplastic layer of both inner and outer periosteum as well as to the absence of movement which ordinarily stimulates callus formation.

Union often occurs by fibrous membrane alone; even narrow fissures may fail to become reunited by bone. As a rule, however, a slow process of bone production and bone absorption goes on, hand in hand, and irregular edges or depressed fragments are rounded off as the gaps are more or less filled in. Occasionally there is an overproduction of new bone, leading to focal or to widespread hyperostoses from either

the outer or inner table. Even defects of some size may at times become entirely ossified, and even when closed by membrane alone they may become so firm and inelastic as to show no pulsation. According to Bergmann, defects cannot be expected to close if they exceed a diameter of 6 to 8 cm., and it would indeed seem that it is rare even for much smaller openings to fill in.

There is a great difference of opinion as to the injurious effect of these bone defects, some holding the view that when extensive they lead, in the course of time, to serious mental symptoms. Personally I do not believe that they are injurious unless accompanied by an underlying lesion of the dura. When the dura is wounded and the scar formation leads to adhesions between overlying scalp and brain, the chronic fibrous changes which result may lead in time to extensive cortical alterations and mental deterioration. With an intact dura, however, such symptoms are less likely to occur.

Treatment.—We are confronted again by the necessity of distinguishing between the management of the fracture itself and the management of its complications. Relatively simple rules can be laid down for the former; for the latter our conduct is largely controlled by physiological laws relating to the circulation of the blood and cerebrospinal fluid under abnormal conditions. In fractures of the vault the indication for surgical intervention is usually deformation of fragments, rather than critical cerebral complications; in fractures of the base it is the reverse, for there intracranial complications are especially serious and deformation is rare.

In compound injuries of the vault we may easily determine the form and estimate the consequences of the injury, and our endeavor should be to thoroughly cleanse the wound, to elevate depressed fragments, to restore a wound in the dura if one exists, and to leave the parts as nearly in their natural position as possible. If the fragments are depressed and wedged it may be necessary to trephine at the edge of the depression before they can be pried into place. Even in the absence of visible depression an opening may be required when cerebral symptoms are present, due to depression from the inner table alone or to intracranial hemorrhage (p. 208).

It is another matter when injuries of the vault are covered by intact scalp, for there may often be great difficulty in determining whether there is sufficient justification to transform a simple into a compound fracture, even for the sake of determining the lesion. It is largely a personal matter and rests with the judgment of the operator; and this in turn depends entirely upon his familiarity with intracranial disturbances which are amenable to operative treatment and his ability to safely cope with them when found. A simple fissure, which crosses the temporal region, of itself needs no surgical intervention, but this is urgently called for when pressure symptoms indicate either a lesion of the meningeal or free extravasation at the base. When simple fractures are accompanied by evident depression surgical measures are indicated, even in the absence of immediate cerebral symptoms, for unelevated

fragments are almost certain to be the source of future trouble, especially if the dura has been injured. The opening must be carefully examined on all sides, for depressed fragments are readily overlooked (Fig. 49). In Fig. 50 is shown a patient with a depressed fracture which had solidly healed, in so far as the union of the displaced fragments was concerned, and the rounding off of their sharp edges, and yet serious mental (left frontal lobe) symptoms resulted. In an old healed depression of this sort (cf. Fig. 43) it is necessary to remove the entire area by a circular incision and either to leave a defect, to replace it by some foreign material, or to cover it by an osteoplastic flap. Occasionally the cup-shaped area may be replaced inverted without subsequent necrosis.

When there is extensive comminution with many loose fragments it may be difficult to determine whether any of them should be removed,

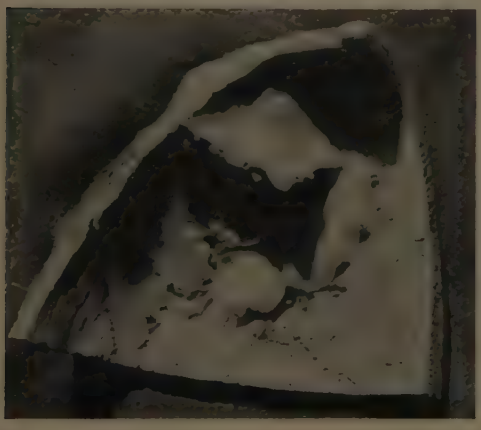

FIG. 49.—UNREDUCED SPICULE IN AN OLD DEPRESSED FRACTURE OF FRONTAL BONE OF FORTY YEARS DURATION.

Leading to epilepsy, an apoplectic stroke and death. (Cf. Fig. 115 for brain of patient. One-half natural size.

FIG. 50.—OLD HEALED "POND-SHAPED" INDENTATION OF LEFT FRONTAL BONE, GIVING FRONTAL LOBE SYMPTOMS.

Depressed area was removed by encircling incision and then replaced, inverted.

owing to possible loss of viability. The dread of necrosis and of infection, though a natural one, is largely an inheritance from our surgical forefathers, and it is a matter of present-day experience to find that fragments of surprising size, even when completely separated, will survive if left in a clean wound. It formerly was the custom to remove all completely detached pieces (Fig. 51). It has been learned, however, that even boiled fragments may heal after reinsertion. I have quite frequently replaced a 3-cm. trephine button after boiling it (owing to some suspicion of its perfect cleanliness), and have never seen it fail to heal in place; it is well known, of course, that an unboiled fragment of this size can always be safely replaced. In the latter case it is probable that bone-forming cells of either surface or of the diploë may remain viable, but in the former instance they have been destroyed and it is to be presumed that the fragment acts only as a temporary stimulus for

new tissue, becoming itself ultimately absorbed. The question of closure of defects will be considered later (p. 249).

The treatment of basal fractures resolves itself largely into the treatment of contusion or compression of varying degrees, for which our therapy is largely restricted to rest, absolute quiet, an ice-cap, sedatives when headache is severe or when there is great restlessness, and to free evacuation of the bowels, preferably with a saline—measures to be observed in practically all cases of cranial injury. The greatest care should always be exercised in handling and in transporting any case of fracture with intracranial symptoms, for the symptoms are much aggravated by any form of jolting.

With the view of preventing infection in case there is bleeding or loss of cerebrospinal fluid from the nose or ears, it is customary to irrigate and tamponade the auditory meatus or the nasal chamber. This procedure, however, can be overdone, and only in case the hemorrhage is profuse is it justifiable to actually pack these orifices, for nothing is more certain to set up a suppurative infection of the mucous membrane. Irrigation of the nose or of the ear, to remove clotted blood and to cleanse the cavities, has an element of danger, and it is preferable to accomplish this by merely wiping out the passages with a sterile cotton swab moistened in a mild antiseptic solution. It is important not to irrigate the Schneiderian membrane in such a way as to produce a sneeze, for on more than one occasion this has been disastrous and the explosive effect has driven septic material into the middle ear or ethmoidal cells and apparently has been the active agent in inaugurating a septic meningitis. After cleansing, the cavities should be loosely closed by a wisp of absorbent cotton or of iodoform gauze if desired, which will serve to take up the secretions and which should be frequently changed if there is abundant discharge. Although by energetic measures we may overcome a local meningeal infection which has started over the hemisphere, we stand practically helpless before one originating at the base, although suboccipital drainage in a few cases has apparently resulted in cure.

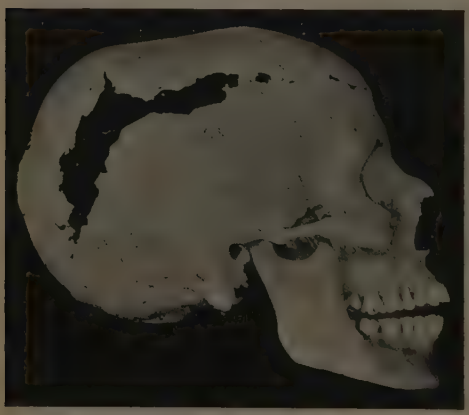

FIG. 51.—DEFECT AFTER EXTENSIVE COMMINUTION WITH REMOVAL OF FRAGMENTS.
Note only partial closure even of frontal fissure.

One can speak somewhat more encouragingly in regard to active interference in case of diffuse hemorrhage. The fatalities from this cause, as will be detailed in the section dealing with Compression, are due to a final implication of the vital centers in the medulla when the

amount of effused blood is sufficient to so increase intracranial tension that they are thrown out of function from anemia. Though this has been well recognized, operative methods of meeting the situation have been inefficient or untried, owing to the feeling of hopelessness in the presence of continual oozing from an inaccessible and often uncertain lesion. Exploratory openings have usually been made over the vault, but, owing to the increased cerebral tension, such openings become filled with a bulging brain; drainage cannot be effective; and a fungus cerebri is often produced.

It is self evident that an opening as near the lesion as possible is desirable, and, inasmuch as most of these fractures enter the middle fossa, an opening low down in the temporal region is most likely to be efficacious. The author's procedure, which has been designated as an intermusculotemporal operation, often meets the needs of the condition. In this operation, by splitting the temporal muscle in line of its fibers and by rongeuring away the thin squamous wing of temporal and adjoining sphenoid, not only is the region overlying the meningeal vessels exposed, so that a chance extradural hemorrhage can be brought to light, but also the dura over the temporal lobes is exposed and the presence or absence of subdural effusion can be determined. The dura should be opened and there will usually be an abundant escape of bloody cerebrospinal fluid, whose evacuation will be aided by passing a curved, blunt dissector down under the temporal lobe. Oftentimes edema, as we have seen, has played the chief rôle in the compression, and we may find that merely a so-called "serous meningitis" is present and that evacuation of a large amount of fluid will diminish the tension. In such case the muscle and scalp may be closed, but if there is continuous bleeding it is well to close the muscle only in part and to leave, at its lower angle, a strip of rubber protective, leading under the temporal lobe as a drain. In case the craniectomy on one side alone seems insufficient a bilateral operation may be performed at the same or at a subsequent sitting, for the procedure is simple and not attended by shock. Its advantages are due to (1) the frequency of the bony lesion in the middle fossa; (2) the fact that cerebral contusions are especially liable to involve the tip of the temporal lobe; (3) the exposure of the meningeal territory and ease of determining the presence of an extradural hemorrhage; (4) the possibility of draining through a split muscle rather than directly through the scalp, and (5) the subsequent protective action of the muscle in case a hernia tends to form in consequence of traumatic edema. The unilateral or bilateral defect in this situation leads to no complications and no subsequent deformity.

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INJURIES OF THE HEAD IN THE NEWBORN.

General Considerations.—A designing Nature has left the child's skull, at the end of its period of intra-uterine life, in a condition in which it may be extensively molded without damaging either the cranium itself or, what is more important, its contents. The cerebrum itself is as yet in a very undeveloped state—a wise provision also—for probably no fully medullated organ could endure even a small degree of the manipulations which every infant's brain must undergo, even at a normal birth. Scalp, bone, and brain, however, despite these provisions, are liable to injury, either individually or all together—the wonder is that they ever escape.

The scalp is thin, delicate, movable, and can be readily peeled away, down to the subaponeurotic layer. The pericranium is relatively thicker than in the adult and is firmly attached by many small blood-vessels, which are necessarily torn when it is rubbed on the underlying bone. At the growing margins of the bone, dura and pericranium are inseparably attached, and, largely owing to these fibrous interspaces, changes in form may take place through tilting or rocking of the bones. This is particularly true of the parietals, for the frontal, temporal, and occipital have bony attachments to the base, and consequently do not yield to the same extent and so are more liable to fracture. These thin, vascular, and elastic shells of bone may become indented without fracture (Fig. 52) and such an indentation of its own accord or from cerebral pressure may spring back into position, promptly or slowly, as the case may be. The thin edges of the bones in particular may be bent and molded to a considerable degree without fracturing.

Parturition injuries are possibly the commonest form of injury to

the head. They vary in their nature all the way from a trifling edematous lesion of the scalp up to an injury of the brain which, if not fatal, leaves the child mentally and physically incapacitated for life.

Lesions of the soft parts, due either to pressure of the head against the pelvic brim or to instruments used in aiding expulsion, are especially common. The former may appear as broad lines of erythema, usually on the left side of the head, the extent of the ecchymosis being considerable when, for example, a large head has been crowded through a narrow pelvis by powerful uterine contractions. An anchylosed coccyx is not an uncommon source of such a bruise. Similar marks may be left by forceps, their situation depending on the position which the head occupied at the time of their application.

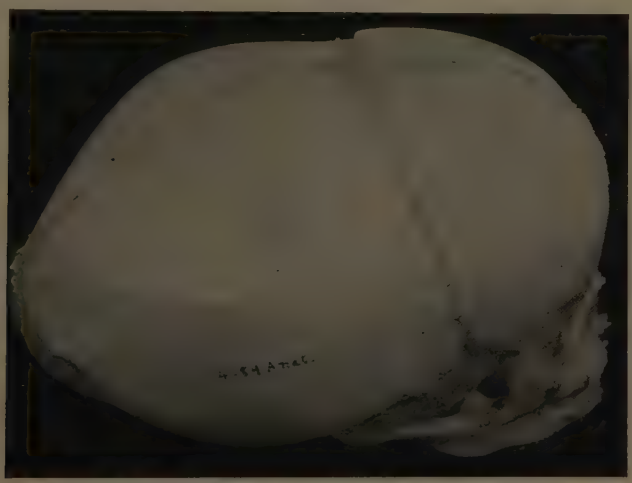

FIG. 52.—INDENTATION OF RIGHT PARIETAL BONE.
Note its wedge-shaped form with radial margins from primary center of ossification. (Surgeon General's Museum.)

A still more common lesion is a circular patch of edema—the so-called **caput succedaneum.** It occurs over the only area on the child's body which, after rupture of the membranes, is not subjected to uniform pressure during the recurring uterine contractions; namely, the circle of scalp which is cupped by the firm ring of slowly dilating tissues making up the parturient canal. Local venous congestion and edema result. It is more common over the posterior superior portion of the right parietal bone, but its position varies, of course, with the character of the engagement. Particularly in face presentations it leads to a most unsightly appearance. The most extreme degrees are usually due to a delayed second stage, though a delay at the pelvic brim may lead to a caput which protrudes into the vagina and may simulate an advancing head or be mistaken for unruptured membranes. Occasionally we may find a double caput when, for one reason or another, the child's head has changed position, but this is unusual.

A caput is of surgical moment merely from the standpoint of diag-

nosis. It does not conform in outline to one of the bones, as does a cephalhematoma; it can be pitted on pressure ; does not fluctuate ; and it disappears in a few days after birth: whereas a cephalhematoma tends at first to augment considerably in size.

Cephalhematoma.—This condition possesses considerable surgical importance, not only of itself, but because it is often a telltale of intracranial stasis. It consists of a subpericranial effusion of blood, usually limited in outline to the ossified portion of one of the parietals. It is said to occur more often on the right side; hence arose the presumption that it results from the same agencies which lead to a caput, and the two may be associated, though this is rather the exception than the rule. Termin and Scheglow, in a study of 103 cases, found no preponderance of right-sided lesions; indeed, a few more than half of their cases occurred upon the left side. Further, about 1 out of every 10 cases possessed a double parietal effusion and rarely (in about 1 per cent.) it occurred over the occipital or one of the frontal bones. The statistics which F. W. Markoe has kindly given me from the New York Lying-in Hospital are quite at variance. There were only 46 recorded cases out of their enormous service; most of them followed prolonged labor, often terminated by instrumentation. The right side was involved slightly more often than the left; the occipital bone was affected six times, once bilaterally; the left frontal once; there was only one double parietal effusion (Fig. 53).

FIG. 53.—BIPARIETAL CEPHALHEMATOMA. (Asa B. Davis's case.)

The fundamental characteristic of these effusions lies in their seat and in their delineation by the outline of the already formed bone.

Etiology.—The condition is necessarily due to bleeding under an intact pericranium, due to the rupture of some of the vessels which connect the newly forming shell of bone with its highly vascularized covering; and were this the result of venous stasis alone from prolonged pressure we would invariably find a cephalhematoma surmounted by a caput, and this is far from our actual experiences. The rupture of vessels can occur when the pericranium is rubbed away in some spot from its bony attachment or in case it is injured during overlapping by the sharp, serrated edges of the osseous shell. The effusion, however, seems usually to start from the center of the bone, from which it spreads toward its edges, rather than the reverse. A temporary indentation

naturally will always lead to some pericranial slipping and thus tend to favor extravasation. I have seen at autopsy in a stillborn child the rarer form of *extradural cephalhematoma*, if it may so be called, without any subpericranial effusion. There was found a thin hematoma about the size of a silver dollar underlying the center of each parietal bone, having elevated the dura about ½ cm. in its thickest part. It is difficult to account for such a condition other than by a double indentation during expulsion, which has injured vascular dural attachments, whereas the pericranial ones had escaped. In serious injuries, therefore, it is possible to have three layers of extravasation—subpericranial, extradural, and subdural—the last in case of accompanying rupture of cortical vessels; and it is not unusual to find the first and third combined. In 2 of my cases of extensive cortical extravasation parietal cephalhematomata of large size have been present, but no connection whatever between the subpericranial effusion and that which spread over the cortex could be demonstrated in either case at the time of operation.

Course.—A cephalhematoma, as a rule, does not evidence itself until a day or two after birth, but when it does appear anything which

FIG. 54.—LARGE CEPHALHEMATOMA IN A COLORED BABY.
Hematogenous infection with the gonococcus unexpectedly found at operation.

causes congestion, such as crying or straining and, above all, the venous stasis produced by intracranial hemorrhage, will tend toward its rapid enlargement until the pericranium becomes greatly stretched and elevated high above the bone. Even when large, however, the hematoma rarely leaves the confines of a single bone, and when there is a bilateral effusion the two swellings remain separated by a deep cleft. They rarely communicate, and it is equally rare for them to break through the pericranium into the subaponeurotic space. The uncomplicated cases begin to subside by the first or second week, though this is not invariable. When absorption is longer delayed the swellings become

surrounded by a ridge of new-formed bone deposited along the elevated pericranial edge, and this may lead to a permanent extracranial deformity. In rare cases a cystic condition may result, the hematoma remaining fluid in its center, clotting and organization having taken place only about the periphery; and in this state a swelling may persist throughout life. At other times the clot may become infected (Fig. 54) and a large abscess form, which, if neglected, may lead to the serious consequences of bony necrosis and intracranial suppuration.

The *diagnosis* usually offers no difficulty, even if the lesion is present at birth, which is unusual, and is surmounted by a caput, which is still more rare. A caput, even though large, rapidly subsides; whereas a cephalhematoma persists and augments in size. A spurious meningocele may occupy the same position, but it pulsates with cardiac and respiratory movements and is reducible, as is also a sinus pericranii—a form of swelling which is commonly mesially placed.

Treatment.—A let-alone policy is usually, and properly, followed in these cases. Surgical measures, however, may be wisely resorted to when there is any unusual delay in absorption. I have made it a rule to open such a hematoma and evacuate the clot when, after two weeks, there is no sign of subsidence. It is a simple procedure and should be more often practised than it is; indeed, there is more likelihood of infection taking place in a long-standing hematoma than for organisms to be introduced during such an operation. The head should be shaved, carefully cleansed, and a knife introduced into the cavity, blade upward, at the basal edge of the swelling. This makes a punctured incision with a fairly long canal, through which most of the semiclotted contents of the blood sac can be expressed. A carefully applied bandage will cause the separated tissues to adhere and in two or three days there will be as little trace of the hematoma as of the operation. A small incision is necessary, since the partly coagulated contents of the sac cannot be evacuated through a hollow needle.

Injuries of the Bones.—The thin cranial bones, in spite of their elasticity and movability, may become indented or broken when undue strain is put upon them. Actual fractures are less common than grooves or indentations. These lesions may occur if an extreme degree of molding is necessitated by a small or a deformed pelvis, or if a difficult labor has called for the use of instruments which further compress the child's cranium; the bones will indent or fissure or break before their tough uniting membranes give way. The degree to which ossification has advanced varies in different infants, and soft, pliable bones may become grooved or indented, whereas others would crack with the same amount of pressure. In order that such a lesion may occur the head must be firmly grasped in the parturient canal and pressure be made against one of the bones by some unusual pelvic irregularity or by instrumentation. Those who have had experience with cranial operations in the newborn can best realize how tough and strong are these thin, osseous shells.

The new bone is laid down from its center of ossification in radiating

lines, in the direction of which, linear splits may occur (Fig. 55); whereas a fracture which crosses these lines makes a jagged and serrated edge.

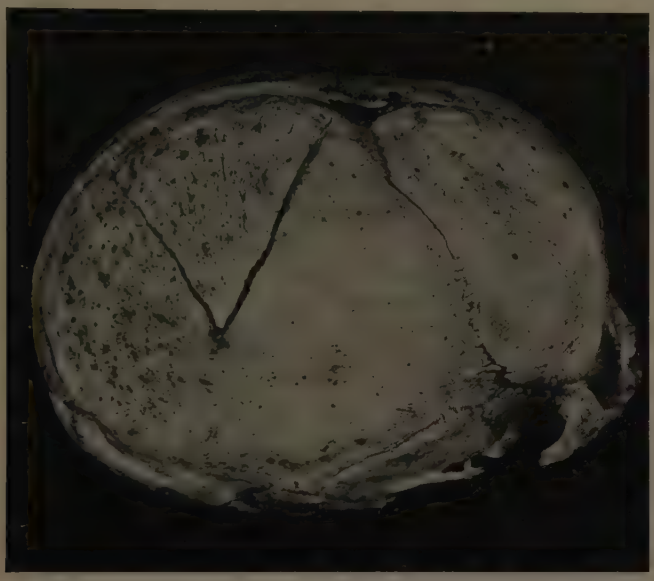

FIG. 55.—SHOWING CHARACTERISTIC TRAUMATIC FISSURES IN THE SKULL OF THE NEWBORN. Radiating from the center of ossification. (Warren Museum.)

Pressure, for example, exerted against one of the parietal eminences will first depress the bone and cause it to underride its opposite neighbor, putting tension on the supporting and surrounding membrane; if greater pressure is used the bone, if sufficiently elastic, will indent (Fig. 55 *a*); and still greater force may lead to radial splits or, in extreme cases, to irregular fractures (Fig. 56).

FIG. 55 *a*.—SHOWING UNREDUCED INDENTATION OF RIGHT PARIETAL BONE. (Massachusetts General Hospital.)

Treatment.—A simple indentation usually becomes reduced of itself, immediately or by the slow influence of pressure of the growing brain. If, however, this does not occur within a week or so, and if the depression is considerable, it should be reduced by operative measures, for the sake of future appearances if for no other reason. A stout, blunt dissector may be introduced through a small opening at the outer margin of the depression and the bone easily pressed

back into place from within if the lesion is not of too long standing. The extensive fractures are commonly an incident of a desperate case

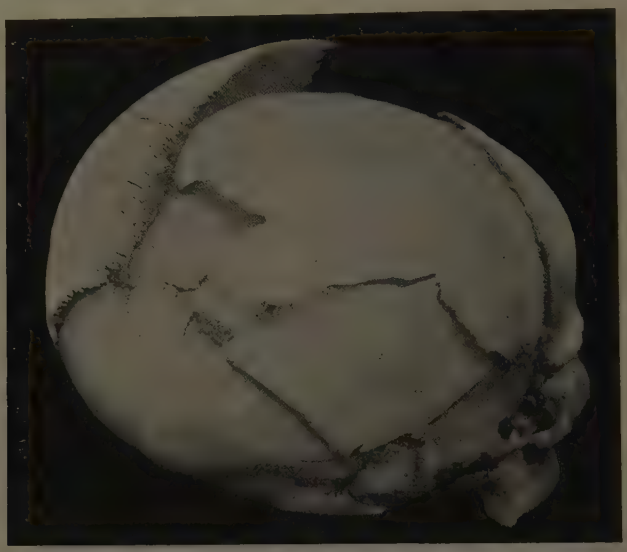

FIG. 56.—INSTRUMENTAL FRACTURE OF THE RIGHT PARIETAL BONE. (Surgeon General's Museum.)

in which extraction has meant the death of the child. Should this not be so, the lesion should be treated on the general principles of cranial injuries. These bony lesions are limited to the parietal in the great majority of cases, though fractures may occur elsewhere; thus, either the os frontalis or occipitalis may be broken away from its basal attachments. Basal fractures also may occur, though they are rare. I have seen such a case with a fissure into the middle fossa which led to a tear in the cavernous sinus, with subsequent sinus thrombosis and exophthalmos (Fig. 57).

FIG. 57.—PROPTOSIS AFTER CAVERNOUS SINUS THROMBOSIS SECONDARY TO BASAL FRACTURE AND INTRACRANIAL HEMORRHAGE IN THE NEWBORN.

Intracranial hemorrhage in the newborn may occur in the absence of any lesion of the bones. Often the first-born of a mother whose childbearing period is nearing its close; there is no more sorry condition in all medicine.

A prolonged and difficult labor, due either to a small pelvis or to the inelastic soft parts of a primipara approaching middle age; extreme

molding of the head with overlapping of the bones; instrumental extraction; possibly, too, an extreme degree of asphyxia leading to stasis and rupture of the delicate cortical vessels—all of these factors combine toward the production of such a lesion. These circumstances, however, are not invariable ones, for the forcible expulsion by a multipara, especially of a premature child, not uncommonly so distorts the delicate skull as to lead to rupture of the vessels. Further, the lesion may occur in breech as well as in head presentations.

Little, an English orthopedist, was the first to call attention to the fact that a history of difficult birth could be obtained in a large percentage of the children who later in life suffer from bilateral spastic paralysis; hence the designation "Little's disease" or "birth palsy" has come to be applied to these late consequences of the lesion.

The extravasation is usually most extensive over the upper and outer surface; and for this reason the motor centers for the lower extremities usually suffer more than those for the arms. The lesion, however, need not be bilateral and, indeed, the effusion of blood and resultant cerebral injury need not affect the motor strip at all; so that from an etiological point of view the term "birth palsy" would only include a small percentage of all the cases of intracranial hemorrhage in the newborn, and when paralysis occurs it by no means always assumes the form of diplegia.

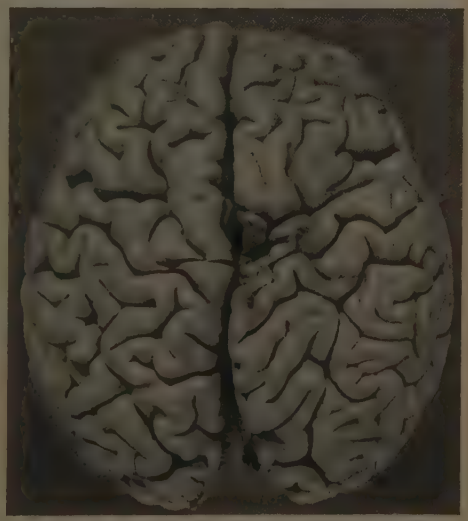

Fig. 58.—Scar of an Old Birth Hemorrhage Occupying the Leg Center of the Right Motor Cortex, having Caused Spastic Monoplegia and Focal Epilepsy.

The inciting factor in the vascular rupture, whether it be a consequence of change of position in the bones which puts a strain upon those vessels which connect the cortex and the dura, or whether passive congestion plays the chief rôle, cannot always be told. We know that extreme degrees of stasis may serve to rupture the delicately supported cortical vessels, even long after birth, as is especially well shown by the "whooping-cough" cerebral hemorrhage of infancy. It would seem, however, that parietal overlapping is the factor which deserves chief consideration. The cerebral veins from the major part of the exposed hemisphere empty into the longitudinal sinus, the larger of these vessels coursing in the arachnoid and pia practically in the region of the central convolutions. On approaching the mid-longitudinal line they leave the cortex and, unsupported, bridge across the subdural space to enter the parasinoidal sinuses; and at this point, therefore, they are especially

liable to rupture, owing to the strain put upon them from overlapping. In extreme cases of parietal overlapping even the longitudinal sinus itself may be torn. We can thus easily explain the greater frequency of implication of the lower extremities, either on one side alone (Fig. 58) or on both, as in the spastic paralysis of the Little type.

Whatever its cause and wherever the extravasation may have occurred, cerebral disturbances of greater or less extent supervene. In the acute condition either a simple, small area of effused blood may be found, usually in the subdural space, occasionally spreading out in the meshes of the leptomeninges; or a thick clot covering an entire hemisphere alone (Fig. 59) or overlying a large part of both may be disclosed. All of the extensive hemorrhages which I have seen have been limited to one hemisphere, and I am inclined to think that the unilateral form of extravasation is the more common. It must not be forgotten, too,

FIG. 59.—EXTRAVASATION FROM ½ TO 1 C.M. THICK CLOT COVERING ENTIRE LEFT HEMISPHERE. Partially removed at operation, which proved fatal.

that effusions other than intermeningeal ones occur; for contusions or lacerations of the brain itself may lead to hemorrhages into its substance. These may become very extensive owing to the venous stasis and to the unresisting, jelly-like consistency of the brain at this age—the "unripe cerebrum of the newborn."

In a distensible child's head, with its open membranous fontanel, an amount of hemorrhage may take place which in corresponding degree in the closed adult skull would lead quickly to fatal compression phenomena. Hence, a large number of these children survive and the lesions which result from the hemorrhage may be multitudinous. We may find only a thickening of the meninges with adhesions over an old superficial scar of the cortex (Fig. 58); we may find a superficial, shallow, saucer-like defect filled with fluid, with the tough, thickened leptomeninges bridging over it; and from these simpler forms there are

gradations, too numerous to mention, up to large porencephalic cavities, which may occupy an entire lobe.

Symptomatology.—Too little attention has been paid to the immediate symptoms of these lesions, whose later effects are so well known. For these infants, if they survive the first few critical days—and they are only too apt to—develop into simple-minded, hemianopic, spastic, or epileptic children. There is usually an interval after subsidence of the immediate symptoms during which false hopes are raised of a perfect recovery, but in a few weeks or months evidence of a defective brain becomes obvious even to other than trained observers.

Among the immediate symptoms may be noted asphyxia and oftentimes delayed spontaneous respiration. The child does not suckle normally and must be fed with a dropper; there may be inequalities in the pupils and evidences of medullary irritation shown in the pulse, which may be slowed, and in the respiration, which is irregular and may even show rhythmic periods; the fontanel is abnormally and constantly tense and evidences of increased intracranial pressure are shown by dilated vessels over the scalp, eyelids, and in the eye-grounds, where hemorrhages not infrequently are to be found; twitching movements may occur, even convulsions, which after a few days may be more or less unilateral. Difficult as it may be at times to determine the presence of a lesion, it is still more difficult to determine its seat and whether it is unilateral or bilateral. Help may be had from the character of the convulsions, from the pupils, and, as in the adult, in a desperate case a bilateral exploration may be necessary. It is to be noted that there are no paralytic symptoms, for the newborn is little more than a spinal animal.

The ideal **treatment** differs in no wise from that of intracranial hemorrhage in the adult; namely, removal of the clot. This has been recognized by many, but surgical aid has been withheld owing to the wide-spread opinion of obstetricians and neurologists that the operation would be useless, if not immediately fatal.

As a matter of fact, the newborn withstands the effects of a cranial perhaps better than any other operation, and with due regard for hemostasis and for preservation of body temperature, the procedure, though a delicate one, can be conducted with much less traumatism to the child's head than Nature often subjects it to during its normal passage through the pelvis. The possibilities of surgical relief are limited to the first week or two after the hemorrhage has occurred; for an old cerebral scar can neither be helped by medicine or the scalpel.

The author has, at this writing, operated upon 9 of these cases with 4 apparently perfect recoveries. In the fatal cases there was an extensive extravasation (cf. Fig. 59) over the entire hemisphere; they were all of them in an extreme condition, and possibly too much was attempted at one sitting in the way of removal of the clot. The time of operation has varied from the second to the twelfth day. In 3 cases a bilateral exposure (Fig. 60) was necessary, and twice a secondary operation.

The method of procedure is as follows: The child is wrapped in cotton and surrounded by heaters; its head is carefully shaved and prepared and light chloroform anesthesia used. A tourniquet of thin, elastic rubber tubing, previously tied in a circle before application and with a longitudinal tape to prevent its rolling over the face, may be used. An omega-shaped incision just within the outer margin of the parietal is carried down to the bone through the scalp and pericranium, and the latter is scraped away so as to expose the thin, serrated osseous edge. Under this a blunt dissector is passed, so that the edge of the bone is tilted up and then, with a proper cutting instrument, the bone is incised in a line conforming with the skin incision 1 cm. or more within the parietal margin. Formerly, blunt scissors, curved on the flat, were used for this purpose, but such difficulty was

FIG. 60.—SHOWING SCARS OF INCISIONS IN A CASE OF INTRACRANIAL HEMORRHAGE IN WHICH A BILATERAL OPERATION WAS NECESSARY.

experienced from the tilting of the blades that a particular form of cutting forceps, modeled on the Montenovesi pattern, has been made (Fig. 61). These will quickly incise the thin bone with the minimum of jar. The parietal is then broken across at its base. It would be possible to elevate the entire parietal, but this would necessitate a larger opening than is required and the replacement would be less satisfactory. If a subdural hemorrhage is present, its dark color will show through the tightly stretched dura. This should be opened by a curved incision some distance within the bony margin, and the superficial clot can usually be broken and lifted off in fragments or irrigated away with a gentle stream of warm salt solution. The dura should then be accurately resutured, the bone replaced, and the skin closed without drainage.

Certain technical complications may arise. One of them lies in the

occasional difficulty of closing the dura, owing to cerebral tension from edema. This may be counteracted by a lumbar puncture and the withdrawal of some of the cerebrospinal fluid, which quickly diminishes the tension. Accurate dural closure with fine interrupted sutures is

FIG. 61.—JAWS OF AUTHOR'S CUTTING FORCEPS FOR INCISION OF CRANIAL BONES IN THE NEWBORN.

essential, for otherwise adhesions between cortex and membranes are likely to occur. In one of my cases a small spurious meningocele was the result of inefficient closure and has persisted now for two years.

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PART III.

THE CEREBRAL ENVELOPES.

MENINGES AND EPENDYMA.

"And there is another danger if you saw the bone down to the meninx and remove it at once, lest in the act of sawing you should wound the meninx."

* * * * * * * *

"For it is not proper that the membrane should be laid bare and exposed to injuries for a length of time, as in the end it may become fungous."—HIPPOCRATES, *De Capitis Vulneribus.*

"It is easier to evolve truth from error than from confusion."—LORD BACON.

Anatomic and Physiologic Considerations.—The Pachymeninx and Its Vessels.—A thorough knowledge of these mem-

branes and the part played in intracranial disease by the fluids which they hold is of prime importance. It is permissible to call attention here to some of the more essential points only.

The *dura* carries on its outer surface certain arteries of surgical interest and it encloses the great venous sinuses. The intracranial dura differs from the intraspinal dura in its relation to the enclosing bone; for the latter has a double, the former only a single inner layer of endothelial cells, its outer surface adhering more or less firmly to the skull and having, especially in the young, an active share in the process of bone formation. This attachment is an intimate one, particularly at the base, from portions of which the dura can be separated only with great difficulty. Hence in linear fractures of the base the membrane is almost always torn; in similar fractures of the vault it may often escape injury. One source of its firm adherence is to be found in the sheath-like prolongation of the membrane along the course of the cerebral nerves. Such a sheath is especially marked in the case of the optic nerve—a fact of importance in the etiology of choked disk. Owing to this firm basal attachment extradural hemorrhages are less likely to occur there than under the vault; this is not an invariable rule, for in certain parts of the middle and posterior fossæ it is readily separable from the bone—a fact which is made use of in exposing the trigeminal nerve and in suboccipital operations. The strength of the dural attachment at the vault is variable; it increases with age, so that the membrane tears in removal; in the young it clings much more firmly to the growing bone at the sutures than elsewhere. In the newborn, for this reason, an extradural hemorrhage ("*internal* cephalhematoma") may be limited to the inner surface of one bone.

As a protection for the brain, the dura, owing to its smooth endothelial surface, is of much more importance than the overlying bone. A dural defect is replaced by scar tissue, which of necessity leads to adhesions between the cortical leptomeninges and overlying cranium or scalp, as the case may be; a dural wound, the edges of which have been accurately approximated, should leave no such adhesions, as the edge is quickly united by proliferation of the endothelial cells. The dura is, in a measure, separable by dissection into two layers—an outer and inner—between which structures like the Gasserian ganglion are enclosed; it furthermore opens to enclose the large sinuses, from the inner edge of which falx and tentorium pass off to partition the cranial space into its three main chambers. These strong membranous partitions play an important part in supporting the hemispheres, and, inasmuch as they can be dislocated but slightly out of their normal position, they have a tendency to limit the pressure effects of a local process to the one compartment in which it has originated. This is especially so with the subtentorial compartment, for the tent-like membrane hung from the posterior edge of the falx is particularly well adapted to support pressure from above and thus protect the important centers of pons and medulla.

The dura deserves chief consideration as a carrier of blood-vessels.

The superior *longitudinal sinus* lies slightly to the right of the median line. It increases in its blood-holding capacity as it runs from the ethmoid to the torcular. In its course it changes greatly in form. On cross-section, except during its middle course, it is of a narrow, wedge shape, the apex of the wedge running down for a considerable distance between the two layers of the falx. During its middle course broad expansions (*lacunæ laterales* or *parasinoidal sinuses*) pass out between the two dural layers for a distance of from 1.5 to 2.5 cm. over the hemisphere (Fig. 62). Into these lateral expansions enter many of the more important of the superior cerebral veins, particularly those which ascend in the sulci bounding the paracentral convolutions, and from them emissary vessels pass through the inner table to communicate with the diploëtic vessels.

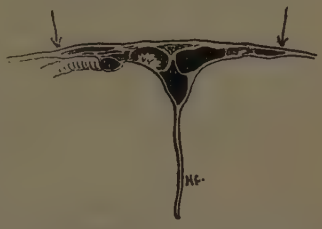

FIG. 62.—SKETCH OF CROSS SECTION OF LONGITUDINAL SINUS IN ITS MID COURSE.
Note width of parasinoidal sinuses.

Into the *lacunæ laterales* project the majority of those bodies known as *Pacchionian granulations*. They seem to be an acquirement of adult life and their function, if they possess any, is uncertain. They consist of tuft-like processes from the arachnoid containing cerebrospinal fluid; and, covered merely by a thinned-out layer of dural endothelium, they project into and are bathed in the blood of the sinus. As they enlarge they may even project through the lateral expansion of the sinus and cause, through pressure, atrophic depressions of varying size in the under surface of the skull. It is for these reasons that injuries to the skull in this situation or efforts to operate there are especially likely to be attended by hemorrhage; for the calvarium cannot be separated from the dura without tearing the emissary veins or injuring the thinned-out layers of the dura covering the granulations. Furthermore, the dura itself cannot be elevated from the brain without injury to the cerebral veins, which, as well as the Pacchionian granulations, serve to bind it to the cortex. Since the lacunæ laterales are sufficiently broad to cover the motor centers for the lower extremities (Fig. 94), it is evident that these centers are difficult of access. Owing to the lacunæ also, ligation of this sinus in its middle course is almost impossible. The longitudinal sinus and its expansions, furthermore, are honeycombed by fibrous bands (*chordæ Willisii*), which pass in various directions and many of which seem to serve as valves at the point of entry for the superior cerebral veins. These vessels enter the sinus by long, obliquely placed channels which pass forward against the direction of the blood current.

At the torcular the longitudinal sinus bifurcates into the *lateral sinuses*, the right being usually the larger. These sinuses lie in the triangular space at the tentorial attachment and, usually with a slight upward convexity, pass (Fig. 94) to the mastoid region of the skull, where, as the *sigmoid sinus*, with a sharp curve they turn downward

to become the internal jugular vein at the foramen of the same name. At the posterior part of the mastoid process there is a foramen for a large emissary vessel which forms a communication between veins of the scalp and the lateral sinus. Injury of these communicating veins in attempting to remove the overlying bone for operative purposes may lead, especially when there is any venous stasis, to profuse hemorrhage, for such an accident amounts to a lateral injury to the sinus itself. Communicating vessels also pass from the sinus to the bone at the occipital protuberance opposite the torcular, and here again especial care must be exercised in removal of bone. During the middle course of the lateral sinuses there are no important vascular communications, and in operations the bone may be rongeured away from the dura without risk of bleeding. Owing to the particularly close attachment of the dura to the petrous bone the petrosal sinuses are important, as they are apt to be injured in the linear fractures which so commonly invade this fragile part of the base. The hemorrhage therefrom either directly enters the subdural space or appears from the external meatus.

A sagittally placed *occipital sinus* connecting torcular with the venous sinuses of the spinal canal lies at the junction of the dura of the posterior fossa and the cerebellar falx. Unlike the falx cerebri this membranous expansion is of variable size and not infrequently both it and its marginal vessel are small or absent. It is my impression that when the sinus is absent its place is taken by large median diploëtic vessels which run in the midoccipital ridge to the edge of the foramen magnum and thence to the condylar foramina. Diploëtic vessels here may prove troublesome in the suboccipital approach to cerebellar operations.

Furthermore, at the base lies another important sinus—the *cavernous*. As it lies alongside of the sella turcica it may be injured by bursting fractures whose fissures so often enter this region, and its companion vessel, the internal carotid artery, may be harmed at the same time, leading to an arteriovenous aneurysm. As it drains the venous blood from the brow and orbit it is liable to infection spreading from these vessels; and when compressed, as by tumor, the resulting venous stasis in the bulbar circulation is supposed by some to be the causal factor in producing a choked disk. When thrombosed it produces an extraordinary degree of exophthalmos (Figs. 78 and 79), usually resulting in blindness.

There has been much discussion among experimentalists concerning the compressibility of the sinuses, and from their peculiar form and protected situation they have been regarded as incompressible. I succeeded in demonstrating that in the dog the longitudinal sinus may completely collapse at an early stage of compression, with consequent venous stasis of high degree. If, with increased tension from any source, a similar collapse may be produced in the *sinus rectus*, with stasis in the venæ Galenæ, an internal hydrocephalus may be produced without the direct implication of these vessels by pressure from a neighboring growth.

The *middle meningeal artery* serves as the chief arterial supply for the dura. Its intimate connection with the membrane is such that in separating dura from skull it clings to the former, though there are often small branches which enter the bone. However, at one place—the anterior inferior angle of the parietal, near the pterion—it grooves or actually may channel the bone, so that separation is often impossible without troublesome hemorrhage. Linear fractures crossing the pterion are also almost certain to injure the vessel.

The nerve supply of the dura is abundant. Unlike the leptomeninges, it contains sensory and vasomotor nerves, the chief supply coming from the trigeminus, although about the foramen magnum there are fibers from the vagus. Headaches I believe to be due to the stretching of the dura or of its expansions.

The Leptomeninges, Ependyma, and Cerebrospinal Fluid.—The *pia*, a delicate and vascular membrane, closely hugs the convoluted surface of the central nervous system; fitting like a glove it dips down into all of the fissures and irregularities. The *arachnoid*, on the other hand, bridges over most of the crevices, and in its relation to the pia may be likened to a mitten drawn over the pial glove. On the top of the convolution where these membranes come in contact they are intricately associated; over the sulci and fissures, and particularly over the irregularities of the base, they are more or less widely separated. Unlike the free subdural space, these subarachnoid spaces are honeycombed by delicate tissue strands, which bind pia and arachnoid loosely together. This loose tissue meshwork is traversed by many of the cortical vessels whose tissue support consequently is slight. The cerebrospinal fluid circulates in these spaces.

The *ependyma* which lines the ventricular cavities consists of a layer of epithelial cells, underlain, for the most part, by a thin layer of neuroglia. It forms a covering for the velum interpositum and the vascular choroid plexuses which curve backward through the foramina of Monro and project into the posterior cornua of the ventricles. Though morphologists have shown us how these important structures develop, their physiological signification remains obscure, and consequently their diseases even more so. They doubtless play the chief rôle in the formation of cerebrospinal fluid, and it is essential that we have, as a working basis, some knowledge of the function of this fluid.

The *cerebrospinal fluid* is not, as was long conjectured, merely a surface lubricant akin to the fluid of the great serous cavities; nor does it act alone as a water-bed, though the comparatively large collections of fluid in the subtentorial cisterns serve in a measure as a support for the important centers of the hind-brain and lessen the jar which they would otherwise receive in case of a cranial injury. Leonard Hill expressed the opinion that the cerebrospinal fluid should be regarded as the lymph of the brain, but, as Halliburton has shown, it is a true secretion and not an exudation like lymph, from which it has marked chemical differences. The subarachnoid space is only remotely connected with the lymphatic system, being fully developed long before the

lymphatics have budded out from the subclavian and iliac veins (Sabin). Observations undertaken for me by Lewis Reford in Mall's laboratory show that the spinal arachnoid is completed first, and in later weeks spreads slowly over the hemispheres. Reford's observations, furthermore, have shown that from the beginning the spinal subarachnoid space is intimately connected with the venous circulation through the rudimentary cerebral sinuses.

There appears to be an active secretion and circulation of this fluid, which, under certain circumstances at least, may form in large amounts. This is shown not only by the copious discharge after certain cases of cranial or spinal injury or in nasal rhinorrhea, but also by the rapid reaccumulation of fluid in a hydrocephalic head after its withdrawal.

Of the manner in which this fluid gathers we are as yet unaware. It may be entirely a transudation from the capillaries of the vascular choroid—a view held by Leonard Hill—or, what seems to me more probable, it may be largely the product of secretory activity of the ependymal cells which line the choroid plexus, the function of which has not been definitely established. However this may be, the fluid originates in the lateral ventricles, whence, passing backward by the median ventricle to the hind-brain, it escapes into the subarachnoid space by way of the so-called foramina of Magendie and of Luschka. From this point the fluid bathes both the cord and brain. It is chiefly, though not entirely, confined to the ventricular and subarachnoid spaces. Outside of the arachnoid there normally exists little free fluid, though it may gradually make its way through this membrane. When exposed in an operation the arachnoid may be seen to exude drops of fluid—to sweat, as it were—but not until it has been pricked in the intergyral spaces will sufficient fluid escape to allow the membrane to settle down closely over the pia—a matter of importance in cortical faradization to be emphasized later.

Once it has emerged from the ventricle and reached the surface of the brain, the fluid may leave the cranial and spinal chambers by forcing its way into the lymph spaces along the course of the nerves, and in this way may pass into the nasal membrane along the olfactory nerves, into the orbital tissues by the ophthalmic and optic, etc., as can be shown experimentally; but this method of escape is by far the least important. Most of the fluid passes directly into the sinuses—into the longitudinal sinus in particular. Key and Retzius long ago expressed the view that the escape takes place through the intervention of the Pacchionian granulations which project into the lacunæ laterales. Foramina of exit certainly exist in this situation, but whether the escape of fluid takes place through the active agency of these granulations may be doubted; for the free escape of fluid by the sinuses may be easily demonstrated in infants and in the higher apes, in whom no Pacchionian villi exist. Whether at the points of entry of fluid there exists some valvular structure akin to the valve where the thoracic duct enters the jugular or whether there be some other mechanism, matters not for

our purpose; the essential thing is the fact that the chief escape takes place into the venous sinuses.

With this knowledge we may understand how infectious processes may block these channels and cause stasis of the cerebrospinal fluid; why thrombosis of the longitudinal sinus may lead to serious symptoms, even though the venous anastomosis may be sufficient to carry away the circulating blood; why congenital hydrocephalus is so frequently unassociated with any demonstrable lesion of the region of the foramen of Magendie; and finally why many of our operations directed toward the cure of hydrops ventriculorum are based on wrong principles of drainage.

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Congenital Anomalies. Cephalocele.—Developmental anomalies, so far as they are of surgical interest and pertain to brain, meninges, and skull, may be considered together; for, as is the case with similar lesions over the spinal region, they are all more or less associated with circulatory disturbances of the cerebrospinal fluid. They are characterized for the most part by a protrusion of the intracranial contents—the so-called cephalocele—through an area where there has been a defective closure of bone and meninges.

Etiology.—Many vague hypotheses have been offered to account for their production: that owing to some irregular division of the brain into its separate parts portions of the primitive cerebral vesicle come to lie outside of the mesodermic coverings; that they are actual neoplasms—encephalomata (Berger); that they are brought about by the traction of amniotic strands which may have become adherent to the primitive nervous system, etc. Many of them may be accounted for by an arrest of development during the early weeks of fetal life, and it has been possible to reproduce some of these lesions experimentally in the lower animals. When a corresponding arrest of development has involved the mid-dorsal strip overlying the spinal cord, the so-called spina bifida results, and though it is customary to describe this lesion under diseases of the spine, it is of greater import to the cephalic end of the nervous system, owing to the almost inevitable accompaniment of hydrocephalus, due to the general disturbance of cerebrospinal fluid circulation. In cephalocele, too, it is probable that the defect through which the protrusion takes place is not the primary factor leading to the hernia, but rather that some intracranial condition leading to

increased tension and associated in some way with the cerebrospinal fluid was present during fetal life.

We know, from our experience with defects of skull and meninges in the adult, that unless, from one cause or another, there is an increase of intracranial tension, there will be no protrusion of the intracranial contents: and it is probable that, without some disturbance in tension, there is likewise no tendency for protrusion to occur in fetal life before the lateral plates have totally enclosed the primitive nervous system. We have seen that the cerebrospinal space forms and contains fluid before this closure is complete, and in case there should be any abnormal increase in the amount of fluid or any obstruction to its outflow by normal channels, it will tend to bulge the meninges through the areas where solid closure by the lateral plates is least advanced, and by so doing it will prevent such closure. Embryologists have taught us that the last point of spinal closure is in the lumbosacral region, which accounts for the frequency of a defect in that situation; in the cranial region apparently the latest closure occurs over the third ventricle.

Varieties.—Cephalocele, like spina bifida, has seats of predilection. They are, as a rule, mesially placed and, occurring in the posterior or anterior parts of the head, are known as *occipital* or *sincipital* cephaloceles. The former are more common and, depending on their position above or below the tentorium, are known as *superior* or *inferior* occipital cephaloceles. The lower form very commonly occurs through a defect which communicates with the foramen magnum and may be accompanied by a spinal lesion as well, so that it may be intermediate between the cranial and spinal forms. In the superior form the cranial defect may communicate with the posterior fontanel. The sincipital or frontal cephalocele usually occurs through a defect situated in the longitudinal plate of the ethmoid near the base of the nose, and it is known as naso-frontal or naso-orbital or naso-ethmoidal, according to the exact site of the defect and the direction taken by the protrusion.

According to their structure and contents, cephaloceles are classified as *meningoceles* when there is a protrusion of membrane alone, filled with cerebrospinal fluid; as *encephaloceles* when a portion of the brain itself protrudes into the sac; and *hydrencephaloceles* or, better, *encephalocystoceles* (Muscatello) when not only is there a protrusion of brain, but this protrusion is itself distended by a collection of fluid communicating with the ventricle. Many subdivisions may be made of each of these varieties.

True meningoceles, contrary to the view of older writers, doubtless are rare, and some authors believe that they never occur. It is a matter which by gross appearances, or even by microscopical studies, may be difficult to determine; and only when there is no demonstrable nervous tissue or ependymal cells lining the sac and no evident communication with the ventricle may we correctly call them meningoceles.

A true encephalocele likewise is rare, though they have been described and are said to occur with greater frequency as a sincipital hernia. They may be encephalocystoceles undergoing retrogressive changes.

These small protrusions of brain without external or internal cystic conditions have been called by Heinecke *cenencephaloceles*.

The most common form is the *encephalocystocele*, and most of the occipital herniæ are of this type (Fig. 63). It is identical in its structure with the myelocystocele of the cord. In this form not only the pericranium and bone are absent, but even the dura may not extend far beyond the cranial defect, so that the outer surface of the thinned and protruding portion of the brain is covered only by pia-arachnoid, which lies immediately under the connective tissue of the scalp, and its inner surface is lined by ependymal cells in direct continuity with those of a median ventricle. The encephalocystoceles of the frontal region communicate with the anterior horn of the ventricle; those of the superior occipital region with the posterior horn; and those of the inferior occipital region usually with the third ventricle. As the circulation of fluid through the arachnoid is interfered with, a superficial

FIG. 63.—OCCIPITAL ENCEPHALOCYSTOCELE WITH HYDROCEPHALUS. Successfully removed at operation: the defect was closed with a bone-flap.

collection of fluid may be found in some cases—a condition indicated by the term encephalocystomeningocele. The layer of cerebral tissue lining the sac of an encephalocystocele may be 1 cm. or more in thickness; but it more often becomes so thinned out that its presence, as a delicate layer of neuroglia, can only be recognized by histological methods, or may even be totally absent, so that the original character of the cyst is determinable by the presence of ependymal cells alone. It is due to this fact that true encephalocystoceles may in gross resemble simple meningoceles.

The size of these congenital herniæ varies greatly. They may be so small as to be hardly noticeable or they may become as large as or larger than the rest of the head. They may be pedunculated and have a communication with the cranial chamber through a small opening or may be sessile and communicate through a large defect. They are

usually smooth, soft, and fluctuating swellings, but may be irregular, lobulated, and quite firm; and they not uncommonly are surmounted by tumor growths—lipomata, fibromata, angiomata, etc.

Diagnosis.—Being congenital lesions and having definite seats of predilection, this should offer no difficulty. They are readily distinguished from acquired hernia cerebri and from spurious meningocele. Dermoid tumors are apt to grow from the same situations, especially sincipital dermoids; and those which overlie a defect in the skull, owing to pulsation, may offer difficulties of diagnosis. Soft angiomata, whose size may be diminished by pressure and which frequently occur at the root of the nose, may be mistaken for them, and it is not uncommon to overlook a cephalocele if it chance to be surmounted by a congenital tumor (fibrolipoma, etc.). The ethmoidal herniæ have often been mistaken for nasal polypi or for other extracranial tumors of the base of the skull.

As the contents of a cephalocele communicate with the cranial chamber, the protrusion increases in size and tension when the child cries or strains. An encephalocele often shows visible pulsation, and even when absent it may be brought out by pressure. An attempted reduction, furthermore, may slow the pulse and lead to other pressure phenomena—respiratory disturbances, elevation of blood pressure, vomiting, convulsions, unconsciousness, etc.—if a considerable amount of fluid is forced into the cranial chamber from the sac. A large "meningocele" is often translucent and its overlying surface may become thinned and excoriated by pressure, so that rupture and infection are not infrequent sequels.

It is unusual for infants possessing such a defect to live long after birth; and, unhappily for the cases which survive, malformations of the brain, hydrocephalus, etc., are a common accompaniment of the lesion, and the few years of life granted to these unfortunate victims are hardly to be desired.

Treatment.—Every possible care should be taken in the large herniæ, particularly those of the occipital region, to protect the overlying skin from excoriation and pressure sloughs. Attempts to reduce the protrusion by bandaging used to be employed. They are useless and even dangerous. Repeated emptying of the sac by puncture, with subsequent bandaging, has been advocated. The withdrawal of fluid by a lumbar puncture will, in the majority of cases, answer the same purpose. Rarely can this be of any permanent benefit, for the fluid rapidly accumulates, despite the exertion of pressure over the collapsed hernia. There have been cases in which this procedure—or even the most unsurgical one of injection of irritating fluids (Morton's and the like) into the sac in the hope of causing obliterative adhesions—is said to have been curative. Such a favorable outcome could only follow when there is a small "hour-glass" connection between sac and cranial chamber, a condition offering still greater prospects of success through operative excision. Other than for palliative or for diagnostic purposes treatment by puncture and injection is wholly undesirable; by compression, unavailing.

Operative measures alone can promise any permanent benefit, and even they may be futile if the hernia is accompanied by a large cranial defect through which the brain has prolapsed, by defective cerebral development, or by other congenital abnormalities. There remains a small group in which operation is justifiable and its effects gratifying. A meningocele with small pedicle may often be successfully removed, the opening closed, and no further symptoms result. The small encephalocele of frontal or occipital region may likewise be closed after amputating or reducing the cerebral protrusion and repairing the meningeal and cranial openings; if they are large, by a plastic operation of some sort. For the purpose of closing such a defect a flap of scalp or of periosteum alone, or one of periosteum and bone alone, or one of all three coverings, may be taken, leaving only the intact dura over the brain at the area from which the flap has been taken. As these operations are done on very young children, as a rule, the thin shell of bone may be easily cut in the desired form, its pedicle cracked off, and the fragment swung and sutured into position. The surgical technic must be of the very best, for a single point of weakness in the healing wound—a stitch-abscess, for example—may lead to subsequent leakage since there is a tendency toward a rapid reaccumulation of the fluid.

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Hydrocephalus is a symptom of disease, not a disease in itself. It may be chronic or acute, congenital or acquired, external or internal. Those cases in which the fluid accumulates from some known cause are spoken of as acquired and the condition is recognized as a secondary symptom; those in which the origin of the condition remains shrouded in uncertainty cannot as yet be properly classified. Hence the slowly progressive form of ventricular hydrops of antenatal origin and of unknown etiology has erroneously come to be regarded in itself as a disease—congenital, idiopathic, or essential hydrocephalus. The condition is brought about in most cases, if not in all, by some obstruction to the natural escape of the fluid, whether it be at some point in the ventricular channels, or at the openings of Magendie and Luschka, or at the points of outflow into the sinuses.

Hydrocephalus Externus.—Inasmuch as the cerebrospinal fluid is primarily secreted into the ventricle, accumulations of fluid on the surface of the brain, whether congenital or acquired, are rare. It is

somewhat misleading, if not erroneous, to designate as "external hydrocephalus" such conditions as the acute edema which follows traumatism, cerebral angioneurotic edema, or the so-called acute serous meningitis of Quincke, in which accumulations of fluid are found in the subarachnoid space. We may, likewise, properly exclude the collections of fluid which fill up the intracranial chamber when atrophic processes lead to a shrinkage of the brain (hydrops ex vacuo or compensation hydrocephalus) as well as the hygroma of the dura mater which may follow pachymeningitis. One occasionally sees a true external hydrocephalus of congenital form in rare instances, when,

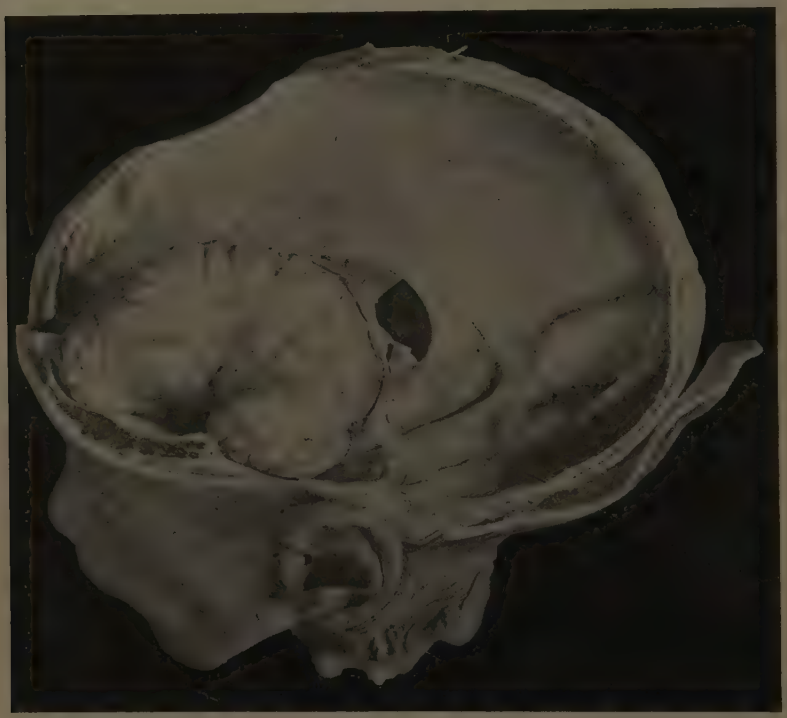


FIG. 64.—HYDROCEPHALUS EXTERNUS, WITH NORMAL MENINGES BUT DEFECTIVE CEREBRAL DEVELOPMENT. (Kindness of Florence Sabin.)

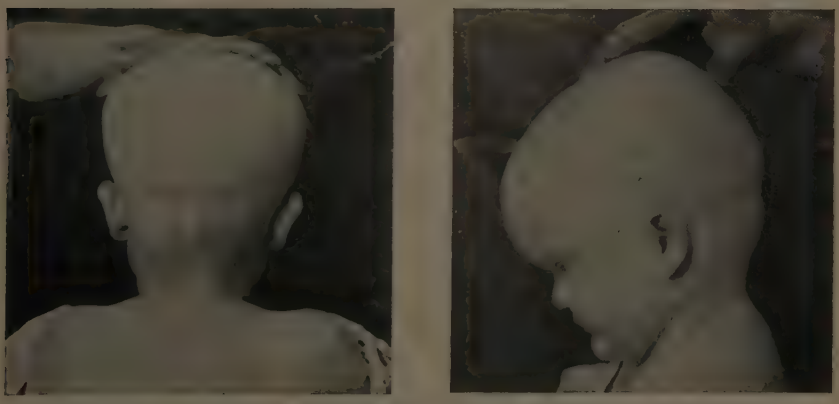
with an undeveloped brain, a normal intracranial chamber is filled with fluid (Fig. 64). Occasionally also in hydrocephalus ventriculorum of the essential form the fluid may come to be external instead of internal through perforation of the overdistended ventricles. This is rare, however, and we know from our surgical experience that the brain will not necessarily collapse and allow ventricular fluid to become extracerebral, even if a large opening be established by surgical measures through the thinned cortex.

Acquired hydrocephalus internus is a process which complicates (1) tumors, (2) meningitis, (3) ependymal inflammations, and (4) stasis

of the venous circulation in the velum interpositum, whether as a primary thrombotic process or one secondary to any of the foregoing lesions. The ventricular dilatation in these cases is usually of acute or subacute onset and rarely reaches a considerable degree without proving fatal.

A tumor so situated that it obstructs the outflow of fluid from the ventricles will lead to hydrocephalus; even small growths situated at the base, and particularly those under the tentorium, will obstruct the flow by pressure against the third or fourth ventricle or iter. (Figs. 65, 66.)

Basal meningitis of whatever nature, provided the exudate serves to obstruct the foramina near the fourth ventricle, is usually the immediate cause of death in the fatal cases of meningitis, and in those which recover is a common source of permanent cerebral disturbance, owing to an incomplete re-establishment of the normally free outlets (Figs. 69 and 70). A primary ependymal inflammation which, like the menin-



FIGS. 65 and 66.—ACQUIRED HYDROPS VENTRICULORUM SECONDARY TO CEREBELLAR CYST (removed at operation).
Leading to separation of sutures of vault in child aged six (natural decompression).

geal infections, may lead to a thickening of the lining membrane of the ventricles is another common source of obstruction. The process here may not infrequently be unilateral from the occlusion of a single foramen of Munro—a condition which may closely simulate tumor.

Owing to their usual occurrence at an age when the skull is closed, the conspicuous feature of congenital hydrocephalus—the large head—is absent, although in the young enlargement may occur and even separation of the sutures take place (Figs. 65 and 66).

Owing to the immediately critical nature of the underlying trouble, the course of acquired hydrocephalus differs from that of the congenital form. In the acute obstructions, particularly those of inflammatory origin in the adult, terminal paralytic symptoms of compression may rapidly follow. It is not exceptional, however, for the complication to run a subacute or chronic course and for the symptoms to fluctuate

according to the ease with which the pent-up fluid escapes; for it may have greater difficulty at one time than another. In its acute and subacute forms the condition is characterized by stupor and by peculiar rigidities, extensor in the lower extremities and flexor in the upper (Fig. 67), due to pressure on the pyramidal tracts; and when there is cerebrospinal inflammation by retraction of the neck as well (Fig. 82, p. 136). In its chronic form acquired hydrocephalus, especially after ependymitis, may lead to some atrophy of the hemispheres and persist for years without disturbing symptoms (Fig. 113, p. 213).

Treatment.—The ideal treatment of acquired hydrocephalus is the removal of the cause of the obstruction. This at times may be accomplished. It is impossible, however, in the acute period of the inflammatory cases, when resort must be had to palliative measures by puncture or by repeated punctures of the ventricle. Occasional cures have been brought about by this means (v. Beck). In the less advanced and unadhesive stages lumbar puncture may be beneficial, but it becomes unavailing after ventricular obstruction has occurred. There is, furthermore, a certain measure of risk in lumbar puncture, particularly

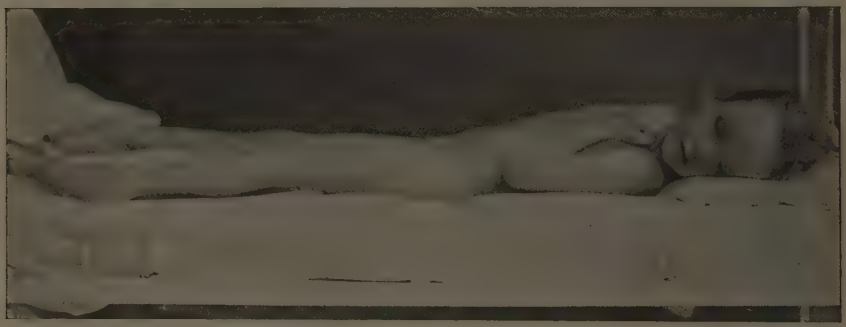


FIG. 67.—SUBCONSCIOUS CHILD SHOWING CHARACTERISTIC RIGIDITIES OF ACQUIRED INTERNAL HYDROCEPHALUS SECONDARY TO TUMOR.

in cases of increased intracranial tension, due to subtentorial obstructions; for sudden removal of the spinal fluid may lead to disastrous and even fatal results, from the crowding down of the medulla into the foramen magnum (Fig. 118, p. 222). Fürbringer and Stadelmann have reported fatalities, and I have seen similar instances of sudden death immediately after a lumbar puncture in a patient with a cerebellar cyst and hydrocephalus.

In the more chronic cases of acquired hydrocephalus the ideal treatment may often be employed. Thus, when a new growth occupies the cerebellum or lies in the cerebellopontine angle, its removal, or even a decompressive operation, may relieve the pressure against the ventricular passages of the mid- or hind-brain and allow the fluid to escape. When it is impossible to remove the cause, as in those cases of old meningeal adhesions which block the foramina of exit of the fluid about the fourth ventricle, or in cases of chronic occlusive ependymitis or irremovable tumor, it may be necessary for us to attempt the formation

of new means of exit. Artificial channels may be made and Nature occasionally aids in accomplishing this even after a simple decompressive operation and puncture of the ventricle (Fig. 68).

Ventricular puncture, therefore, may be necessary (1) for diagnostic and (2) for therapeutic purposes.

For diagnostic purposes it may be demanded in cases of inflammatory obstruction or in conditions of increased intracranial tension in which an exploratory craniotomy has failed to disclose a lesion of the brain and only brings to light evidences of abnormal tension. This is particularly apt to occur when a misdirected exploration of the hemisphere has been undertaken in cases of unlocalized basal tumors. All simple

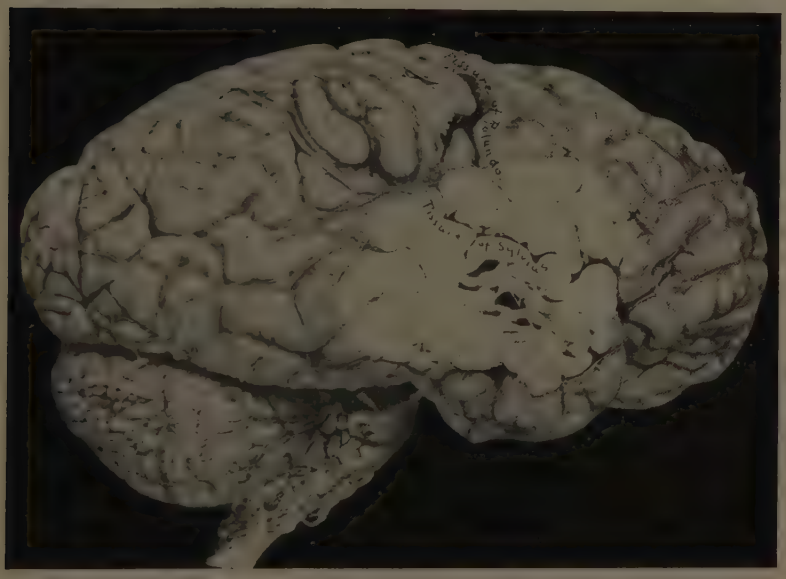


FIG. 68.—CASE OF ACQUIRED OBSTRUCTIVE HYDROCEPHALUS FROM TUMOR OF CORPORA QUADRIGEMINA (cf. Fig. 122, p. 227).

Relief for many months by decompressive operation. Herniated portion of brain shaved off after removal showing new-formed channels of exit for fluid between ventricle and superficial arachnoid spaces. (Contrast area involved in decompression with Fig. 130, p. 235).

decompressive operations for tension should be followed by an exploratory ventricular puncture, unless the lesion is known not to be an obstructive one.

For therapeutic purposes it may be carried out in those cases of obstruction in which the foramina of outlet at the fourth ventricle have been occluded, and when there is reason to hope that with a subsidence of the active process the acute internal hydrocephalus may become relieved by a reopening of the natural channels of outlet for the fluid. Von Beck accredits Bergmann with the first deliberate attempt, in 1888, to treat a case of obstructive meningitis (tuberculous) by ventricular puncture. Since then the method has come into fairly general use.

It can be performed without risk, provided the operator is sufficiently familiar with the ventricular conformation to enable him, even in the absence of dilatation, to enter the cavity without penetrating the basal ganglia or without producing hemorrhage from injury to the choroid plexus or the pial vessels which dip into the sulci. Avoidance of the island of Reil, the situation of which is indicated in Fig. 94, is especially needful, since hemorrhage is almost certain to occur if the exploratory needle passes through it; and the same thing applies in lesser degree to the penetration of the sulci.[1]

It consequently is necessary to enter the needle in such a way that after it penetrates the chosen non-vascular point on the crest of a convolution it will enter the subcortical white matter and pass directly to the ventricle without crossing any of the involutions of the vascular pia-arachnoid. Specific rules for desirable points of entry have been

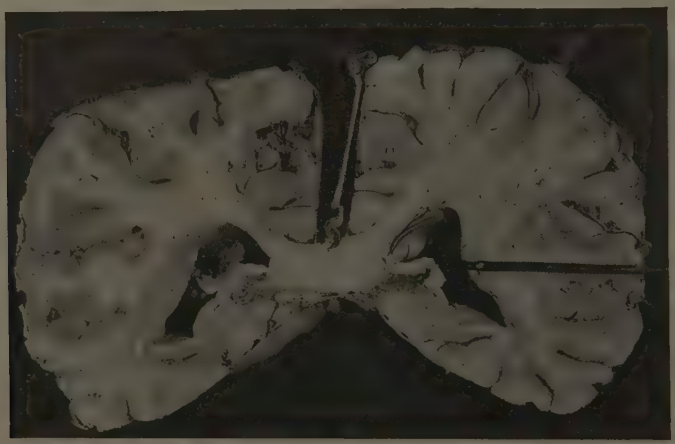


FIG. 69.—CASE OF FATAL, ACUTE, OBSTRUCTIVE HYDROCEPHALUS DUE TO MENINGITIS. Needle introduced into lateral ventricle at Keen's point of election.

given by numerous surgeons. The two that are most frequently adhered to are those of Keen and Kocher. Keen's site of election is at a point corresponding with the posterior end of the temporal line, about 3 cm. behind and an equal distance above the external auditory meatus. In this situation the needle should enter the posterior part of the first temporal convolution and should be directed toward the summit of the opposite pinna. At a depth of about 5 cm. the ventricle will be entered at its widest part; namely, where the lateral and posterior cornua are given off from the body of the ventricle at the posterior end

[1] In about 40 cases of ventricular puncture carried out for one cause or another I have only twice met with accidents from bleeding. Once a vessel at the edge of the insula was punctured from using a sharp-edged aspirating needle; again, an unsuspected angiosarcoma was punctured and led to a serious subcortical extravasation.

of the thalamus (Fig. 69). This is a desirable situation, particularly in those cases in which the temporal lobe has been exposed in exploration for an otitic abscess; for not infrequently, when no abscess has been found, it may be necessary to determine whether the pressure symptoms are due to an obstructing hydrocephalus from a basal meningitis.

Kocher advocates puncturing through the frontal lobe at a point $2\frac{1}{2}$ cm. from the middle line and 3 cm. anterior to the central fissure—a point lying somewhat in front of the bregma (Fig. 70). The needle must penetrate 4 or 5 cm. before it reaches the ventricle and should be directed somewhat downward and backward. The ventricle at this situation is broad, extending fully 2 cm. from the middle line, and there is practically no risk of hemorrhage during the passage of the needle. With experience and after practice on the cadaver punctures may be safely

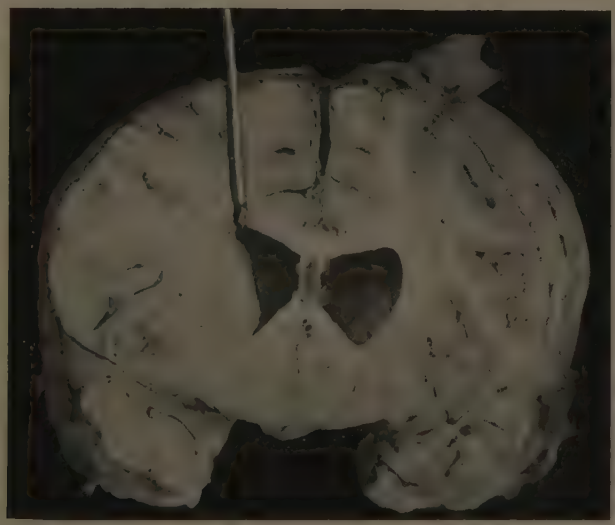


FIG. 70.—SECTION OF SAME BRAIN AS SHOWN IN FIG. 68.
Needle introduced through Kocher's point of election.

made, not only at the points of Keen and Kocher, but elsewhere if need be—through the anterior pole of the frontal lobe, through the pole of the occipital lobe, etc.; but these methods are more hazardous than those detailed above, and should only be undertaken by operators who are particularly familiar with intracranial work.

In infected cases with a beginning external meningitis there is always a certain risk of inoculating an uninfected ventricle. The same accident has occurred owing to the passage of an occluded needle through an abscess and then into the ventricle. A trocar should not be used. It is advisable to employ a needle with a sharply blunt point, which will pass by vessels without cutting them. The openings in the needle should be on the side and not upon the point, else they become plugged by brain matter.

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Hydrocephalus internus sive ventriculorum of the congenital, chronic, and progressive type, owing to the distensibility of the infant skull, presents—except in its very incipient stages—a clinical picture which could be mistaken for no other.

Etiology.—Hereditary influences play a part, and familial types have been recorded, with several afflicted children in one family. It is generally conjectured that some form of fetal disease—syphilis or rachitis—is responsible for the condition. Its association with congenital lues in particular has frequently been observed; but it may be noted that lower animals, not susceptible to syphilis, may have hydrocephalic offspring. Heinecke supports the view that the trouble arises in an abnormal increase in the amount of fluid secreted, rather than in some obstacle to its escape. Both factors doubtless play a part.

Morbid Anatomy.—Occasionally at autopsy there are found about the roof of the fourth ventricle definite thickenings suggestive of some prenatal inflammation, which apparently has led to the obstruction. In such a condition the therapeutic indication is clear; namely, the establishment of a channel of outflow by an artificial opening which connects the ventricle and the external subarachnoid space.

More often, however, there is no evidence of these meningeal thickenings, and the lateral ventricles may be freely emptied by tapping the lumbar subarachnoid space. In such cases the "block" must lie elsewhere than at the foramen of Magendie, presumably at the points of exit for the fluid from the cranial chamber, where there may be some congenital anomaly which prevents the normal outflow. Be this so, it naturally is futile to establish a communication between lateral ventricle and subarachnoid space, into which the fluid already finds its way.

We have already seen that hydrocephalus is a usual accompaniment of cephalocele and spina bifida, and the hypothesis has been offered that these conditions are primarily due to some early disturbance of the cerebrospinal circulation which has prevented the normal closing in of the primitive nervous system. It must be realized that such a circulatory disturbance is not necessarily a permanent one, but may subside. Only when the obstructing lesion has become recovered from, can the spina bifida or cephalocele be removed and hydrocephalus fail to develop. Mild degrees, even of chronic congenital hydrocephalus, have been known to become stationary through natural processes; few,

if any, of the rapidly advancing ones have ever been cured by operative measures.

The appearance of the skull is striking, the large, thin, flaring cranial leaflets being perched on the small facial bones like the petals of a single water-lily on its calyx. The bones themselves are thinned and atrophied in places, so that pericranium and dura may meet (craniotabes). There is apt to be an abnormal number of wormian bones. The frontal, temporal, and occipital wings, instead of arising vertically from the base, overhang, so that the squamous wing of the temporal, for example,

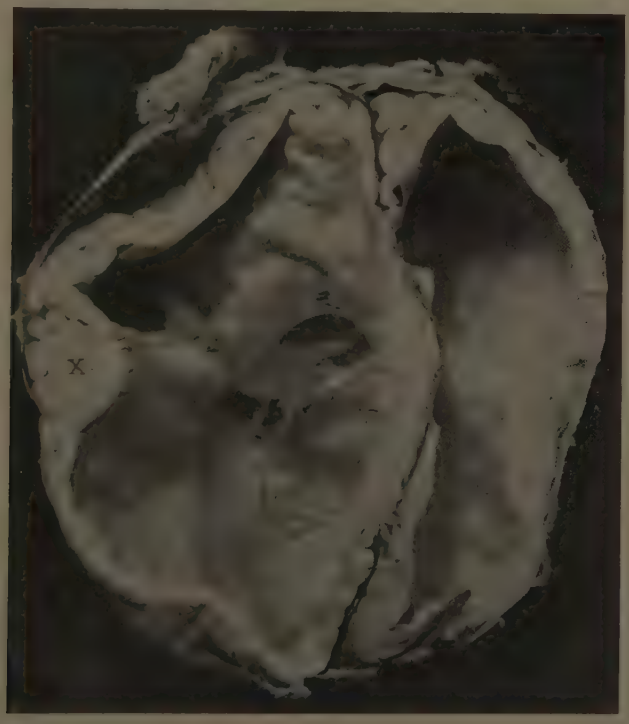

Fig. 71.—Advanced Grade of Chronic Internal Hydrocephalus with Extreme Thinning of Hemispheres except at Pyramidal Tract (*X*).
Note enormous size of foramen of Monro. Circumference of head, 70 cm.

becomes almost horizontal and overlies the zygoma in such a way as to almost obliterate the temporal fossa. The irregularities of the three basal fossæ are slowly pressed out, so that the sphenoidal and petrosal ridges separating them no longer project as prominent watersheds. The base, however, does not participate in the general enlargement which the other bones undergo. In extreme cases the brain itself becomes ballooned out by the gradual increase of fluid, so that in places it is of paper thinness. Not only the ventricles, but the communicating passages also, are all widely dilated; the iter is distended and the foramen of Monro may become large enough to admit three fingers (Fig. 71).

The corpus callosum may be drawn out into a thin sheet and the much distended septum lucidum often gives way, leaving a direct communication between the lateral ventricles. The commissures between the basal ganglia usually remain intact, though they may be drawn out to a length of 2 or more centimeters (Fig. 72).

Beyond its undue amount there is no characteristic abnormality of the fluid, either in saline, albuminous, or cellular elements. The amount may be enormous. In one of my patients the ventricle held 3 liters, and even larger amounts have been recorded.

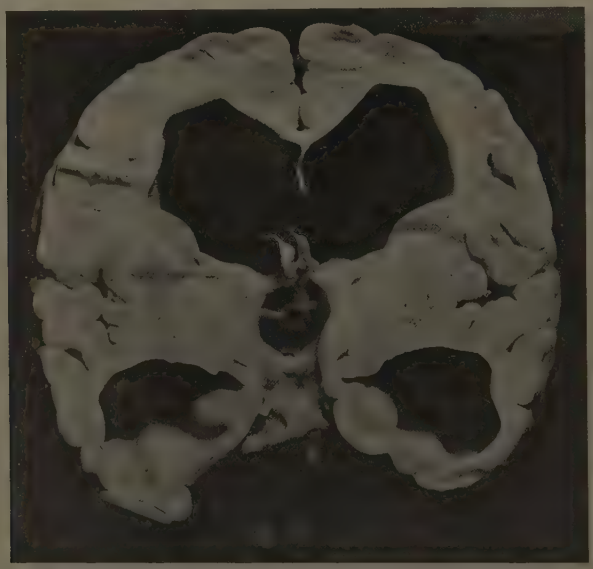

FIG. 72.—MODERATE DEGREE OF VENTRICULAR DISTENTION IN CHRONIC INTERNAL HYDROCEPHALUS. Note great widening of iter; stretching of commissures; and rupture of septum lucidum.

Symptoms and Course.—The external appearances presented by an advanced case of external hydrocephalus are unmistakable (Figs. 73 and 74); a cranial chamber enlarged out of all proportion to body and face; the enormous and tense fontanels; the cranial bones of the vault widely separated even where they should be together, so that the midparietal, midfrontal, parieto-temporal, and parieto-occipital sutures, bridged over by tense membrane, may all be open for 1 cm. or more; the bulging of the frontal, temporal, and occipital bones; the thin scalp, with its sparse hair and dilated vessels, which are thrown into prominence on account of the intracranial venous stasis; the expressional characteristics due to the tilting of the ears, with their wide intertragical notch and slit-like meatus; of the eyes, which are displaced by the downward bulging of the orbital roof, and are covered chiefly by lower lid owing to the upward pull of the tight scalp upon the palpebral angles. The palpebral cleft is narrow and the upper lid, when smoothed out, shows a network of dilated vessels.

The weight of the fluid may be such that these children are unable even to turn, far from raising the head, and unless special pains are taken to frequently change the position, decubitus may result. The circumference of the head may often reach 70 or 80 cm., almost twice that of the normal. As crying increases the intracranial tension, hydro-

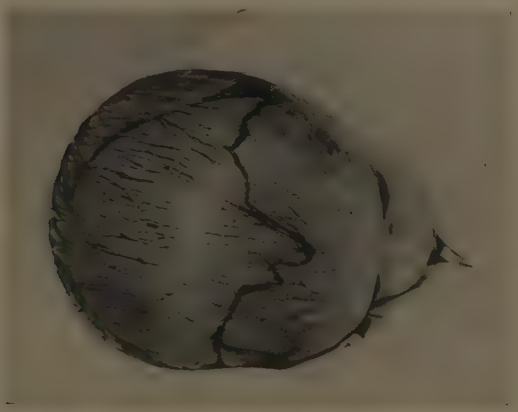

FIG. 73.—ADVANCED STAGE OF CHRONIC INTERNAL HYDROCEPHALUS.
Size of tense fontanels outlined on scalp.

cephalic children, if properly fed, are apt to be quiet. "Hydrocephalic, therefore good," is an epigram of some writer. They are, for the most part, feeble and poorly nourished, and even if the process, once advanced, becomes stationary, they are apt to be carried off by intercurrent infections.

FIG. 74.—SAME CHILD AS FIG. 73, SHOWING CHARACTERISTIC FACIES.

Should they survive, they remain physically and mentally backward, and even those rare cases which have survived to adult age have little educational capacity. There are, nevertheless, some milder grades of the chronic congenital form in which the process becomes arrested and normal physical and mental development may not be interrupted. Except in cases which advance rapidly or are outspoken ones at or soon after birth, there is always hope that the process may come to a stand-

still and that simple measures, like the occasional withdrawal of fluid, may suffice to check its advance.

Diagnosis.—Certain cases of rachitis may resemble hydrocephalus, owing to the large head, delayed closure of the fontanel, the craniotabes, and flexibility of the edges of the cranial bone. The characteristic deformities of the face, however, are absent; there is no evidence of venous stasis shown in the vessels of the scalp, eyelids, or fundus oculi; the fontanel is not tense; and, furthermore, evidences of rachitic changes in the skeleton elsewhere suffice to differentiate the two conditions. Hydrocephalus and rachitis may coexist, since the victims of the former trouble often suffer from malnutrition. In doubtful cases the diagnosis may be determined by a lumbar puncture.

Though its recognition may be easy, there may be difficulty in determining the variety of hydrocephalus, whether congenital or acquired, external or internal. The congenital form, however, is usually apparent at or soon after birth, being more or less latent only in the low grades, and in those cases in which it is accompanied by a spina bifida; for in them the cranial enlargement often does not evidence itself for several months. A febrile illness, as meningitis, or symptoms produced by the growth of a tumor, are antecedent to the acquired form.

Treatment.—The therapeutic indications are purely mechanical ones and should be directed toward the re-establishment of the circulation of cerebrospinal fluid, either by its original channels or, in case they have become permanently occluded, by the establishment of new ones.

Simple tapping of the ventricle is a procedure of ancient record, and in case the distention is great the cavity may be safely reached from any point—through the fontanel, even through the nose (Bouchert) or the roof of the orbit (Langenbeck). After tapping, however, whether by the ventricular or lumbar route, reaccumulation is rapid, and even after the withdrawal of a liter of fluid the fontanel in a few hours may become as tense as before. Hence arose the idea of establishing permanent drainage—a method whose originator in this country was W. W. Keen. Keen, Ayers, Robson, Frank, Baltze, and others have all reported cases in which the attempt was made by ventricular drainage to establish a communication between ventricle and subarachnoid space, a desirable procedure in case there is an obstruction at or about the foramen of Magendie, but a futile one should it be patent, as it seems to be in most of the congenital cases. In a series of some 30 cases I have found that only once was it impossible to empty or partially empty the ventricle by a Quincke lumbar puncture.

Senn advocated drainage between the arachnoid spaces and the subaponeurotic layer of the scalp by inserting small tubes through trephine openings; but the tubes invariably become blocked by cortical matter and the scalp does not readily take up the fluid. Essex Wynter and Quincke have both attempted to establish a communication between the spinal subarachnoid space and the surrounding tissues. This was attempted by Quincke by a blind incision of dura and arachnoid after

a puncture, in the hope that fluid would filter out into the tissues. Wynter performed a laparotomy for this purpose. The writer's method of *retroperitoneal drainage by a combined laparotomy and laminectomy* has been constructed upon similar views, and the steps are briefly as follows:

It is essential in the first place to determine if possible where the obstruction lies, for if it is evident that the foramina of Magendie and Luschka are occluded, some method of direct ventricular drainage must be resorted to. As the *first step* a lumbar puncture is performed, the tension of the fluid is registered, and if an amount sufficient to demonstrate that it must come from the ventricle can be withdrawn, the needle is removed and the fluid analyzed.

The *second step*, carried out some days later, is to determine whether the child will withstand the withdrawal of a large amount of fluid, for though I have never seen convulsions, collapse, etc., from this source, such accidents have been recorded by Keen and others. To do this, a combined puncture of the lumbar region and ventricle is performed. A long glass tube of small caliber connects, by a short rubber tube, with each needle, and the fluid, when lumbar or ventricular space has been entered, spurts up into the tube to its tension level, about which it fluctuates with the cardiac and respiratory rhythm. If the foramen of Magendie is open the fluid seeks the same level in both tubes, and when either of them is dropped and the fluid allowed to escape the level in the other falls. Thus, the ventricle may be emptied by either tube—rapidly by the ventricular, slowly by the lumbar—and I have withdrawn in this way from the lumbar subarachnoid space alone as much as a liter of fluid. The tubes are then withdrawn, the small scalp wound closed, dressed, and the fluid allowed to reaccumulate. A comparative chemical analysis of the fluid taken from the two sources should show them to be the same. When thus demonstrated that the ventricular fluid already communicates by natural channels with the subarachnoid space, it becomes evident that an additional operative communication between ventricle and the subarachnoid spaces over the hemisphere is superfluous and unavailing.

The indication is clear that one must find some other means of escape for the fluid, and I have attempted to drain into the retroperitoneal space as follows:

Third Step.—It having become established (1) that the ventricle can be emptied by the lumbar route and (2) that the withdrawal of fluid is not prejudicial to the child's wellbeing, the following procedure, after an interval of some days, is carried out. A laparotomy is performed; the posterior layer of peritoneum to the left of the rectum is split; the body of the fifth lumbar vertebra just under the bifurcation of the vessels is exposed; the bone is trephined by a specially constructed small-caliber trephine, and one-half (the female portion) of a silver cannula, exactly the size of the trephine, is inserted and held in position. The child is then turned on its face and a laminectomy is performed; the subarachnoid space is opened, the strands of the cauda separated, and the posterior half (male portion) of the cannula is invaginated, so that it locks into the portion inserted anteriorly. Both wounds are then closed. The fluid for a time finds its way into the peritoneal cavity, but ultimately only into the retroperitoneal space, whence it is taken up by the receptaculum chyli, as experimental observations have shown.

It can be seen that this combined lumbar method is especially desirable in cases of hydrocephalus complicated by spina bifida, a radical cure of which may be made in association with the posterior part of the operation. I have carried out this procedure, which is briefly recorded here for the first time, in 12 cases, with a considerable measure of success.

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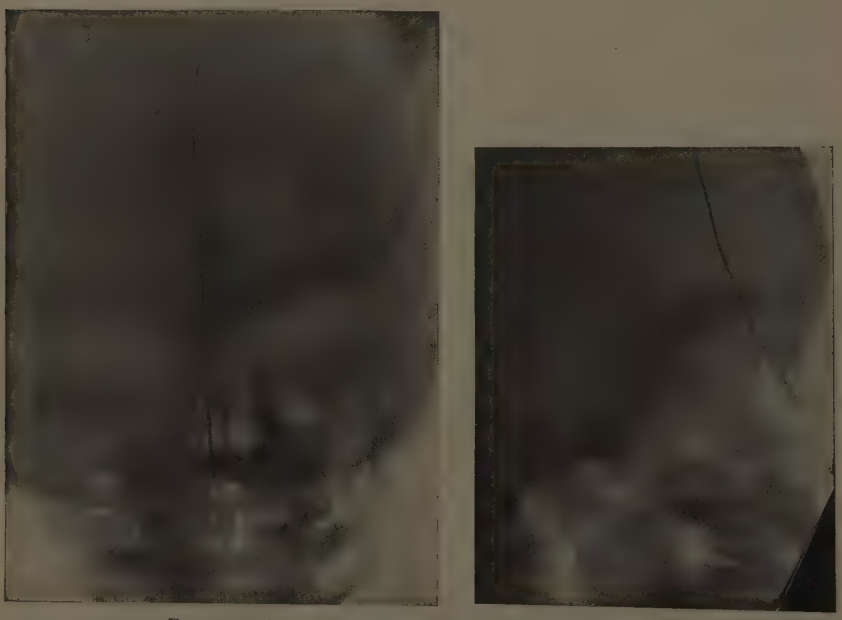
Cerebrospinal Rhinorrhea.—A discharge of cerebrospinal fluid from the nose may occur (1) in consequence of an injury; (2) as the result of chronic hydrocephalus; or (3) spontaneously.



FIGS. 75 and 76.—CASE OF CEREBROSPINAL RHINORRHEA.

Patient with basal fracture of os frontalis; intermittent discharge of fluid with pressure symptoms during dry interval; death from meningitis. Probe introduced through traumatic opening and entering between frontal lobes. (Harmon Smith's patient.)

An external injury, such as a stab-wound, which has served to open either the basal cysternæ or the spinal subarachnoid space, may be followed by a long-continued outflow of cerebrospinal fluid. It is not determined whether this persistent discharge represents merely the

amount of fluid which is normally secreted, but which escapes through its traumatic rather than by its normal channels of exit, or whether the fact of withdrawal of the fluid, by diminishing its normal pressure and thus making the intracranial venous pressure greater than that of the fluid, leads to an abnormal increase in its secretion. It is possible that both of these explanations may account in part for the large amount of fluid which is seen in some of these cases.

Occasionally after fractures of the skull an intermittent discharge of cerebrospinal fluid from the external ear or from the nose may continue for months (Vieusse; Mathiesen) (Figs. 75, 76). Again, it is not an uncommon sequel of cranial operations which have disclosed, from one cause or another, a degree of cerebrospinal-fluid stasis, a condition which subsequently has led to a breaking down of the exploratory wound with external discharge of fluid. Such accidents are particularly frequent after operations for the closure of congenital cranial defects (cephalocele) associated with hydrocephalus. Indeed, in certain cases of chronic hydrocephalus in the adult there may occur an intermittent discharge of fluid from the nose, associated with relief from pressure symptoms. Often no communication between the cranial chamber and the nasal cavity can be demonstrated even at autopsy, and it is probable that the fluid may find its way through the lymphatic channels or along the perineural sheaths of the olfactory nerves. In the ethmoidal region there is the slightest possible separation between dura and mucous membrane (Fig. 77).

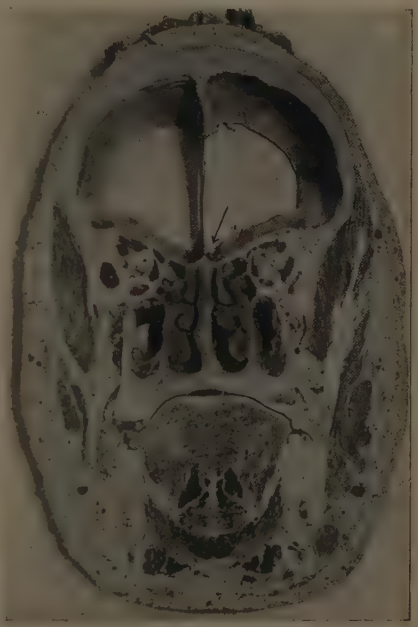


FIG. 77.—CORONAL FROZEN SECTION SHOWING THE CLOSE PROXIMITY OF DURA AND ETHMOID CELLS.

The thin plate of bone (arrow) perforated by olfactory nerves, is a common seat of basal fracture and here cerebrospinal fluid often escapes into the nose.

More rarely, without cranial injury or evidence of intracranial lesion, the fluid unaccountably finds its way into the nose. These spontaneous cases of cerebrospinal rhinorrhea must be distinguished from rhinorrhea of purely nasal origin—from nasal hydrorrhea, from so-called dropsy of the antrum, from the escape of water which has been inspired and temporarily retained, from copious lymphatic discharge, etc. A number of remarkable cases have been recorded, one of the most carefully studied being St. Clair Thomson's. The history is usually that of a young adult, who, after suffering from headache, faintness, or occa-

sionally from definite pressure symptoms, suddenly becomes relieved on the occurrence of a discharge of clear fluid, usually through only one of the nostrils, more often the left. If the patient's head is tilted forward so that the fluid will not flow into the pharynx and be swallowed it may be collected. The discharge may persist without intermission for months in some cases and yet no meningeal infection result. It may amount to 250 cc. or more in the twenty-four hours. It is, however, more usual for the flow to intermit; cessation occurs after pressure symptoms have been relieved and lasts for a variable time, even for months, when the cycle is once more gone through with. There is no known method of treatment.

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Sinus Thrombosis.—We may distinguish three varieties: In one—primary or marasmic thrombosis—the process arises spontaneously in debilitated individuals; in another, a rare form, it is secondary to traumatic or operative injury; in a third, it is secondary to infective processes. Inasmuch as the cerebral circulation is almost certain to be compromised, owing to the venous stasis; inasmuch, too, as the escape of cerebrospinal fluid may be greatly impeded, so that cerebral edema or acute hydrocephalus may result; and, inasmuch as in the infective cases meningitis or pyemia is likely to ensue, thrombosis of an intracranial sinus is a serious malady.

Primary marasmic sinus thrombosis is a condition rarely recognized during life and possibly often overlooked at autopsy, though it occurs next in frequency to thrombosis of the pelvic and femoral vessels. It is known to occur most often in debilitated people, especially at the extremes of life—in infants after wasting enteric diseases, in adults after prolonged fevers. It may be the terminal event in tuberculous or malignant disease.

The relatively wide lumen of the sinuses, their fairly rigid walls, and the fact that the cerebral veins for the most part empty into them against the direction of the current, are all given as causal factors. The longitudinal sinus is most often involved, perhaps because of the many septa which bridge across its triangular channel.

When once under way the thrombotic process may spread and involve many or all of the sinuses or may even extend into the cerebral veins and lead to softening. It may, however, remain limited to one sinus, and circulation may become re-established through a rechanneling of the thrombus. This, however, is rare. The most profound intracranial disturbances follow occlusion of the sinus rectus.

The *symptoms* are apt to be masked, inasmuch as they usually occur

at the end of a prolonged illness. When outspoken they may be mistaken for a tumor. The rather sudden onset of intracranial stasis leads to headache, delirium, stupor, perhaps vomiting and convulsions, to dilatation of the extracranial vessels over the scalp, in the eyelids and in the retina, where, owing to the stasis both of venous and of cerebrospinal fluid circulation, a choked disk should appear early.

Traumatic non-septic sinus thrombosis is rarely seen, for an injury the result of a cranial fracture or one produced by excessive cranial deformation at parturition will usually be fatal from hemorrhage and cerebral compression. If, however, a wounded sinus is disclosed by a prompt operation, it may be packed and a local thrombosis may take place. This need not necessarily advance and, either by collateral circulation or by final re-establishment of circulation through the clot itself, can be completely recovered from.

With a single exception any one of the sinuses which are exposed to accidental or operative injury may thus become occluded by a circumscribed process without marked symptoms—even the posterior part of the longitudinal sinus; for, owing to the irregularities of its channel, a local thrombus need not entirely block the blood stream. The notable exception is the cavernous sinus, the occlusion of which invariably leads to symptoms which are unmistakable. We have seen that the venous circulation of the brow, of the orbit, and of the globus oculi itself passes in large part backward through the ophthalmic veins to this sinus. Hence its occlusion leads to marked congestion, particularly evident in the soft orbital tissue. The exophthalmos of stasis origin results; there is extreme swelling, with ecchymoses of the lids and conjunctiva; extravasations rapidly appear in the edematous retina; and the venous radicles radiating toward the orbit from forehead, nose, and temporal region are greatly dilated. Blindness is almost inevitable.

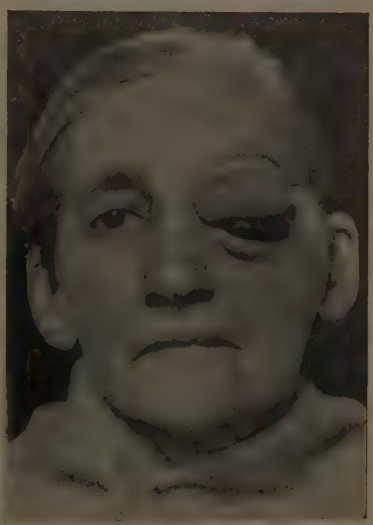

Fig. 78.—Exophthalmos with Extreme Edema of Lids and Conjunctiva Following Traumatic Non-septic Cavernous Sinus Thrombosis.

I have seen two cases of non-septic cavernous sinus thrombosis (Figs. 57 and 78). One of them occurred after a Gasserian ganglion operation in which the sinus had been injured. The sudden exophthalmos—the telltale symptom of the lesion—occurred on the twelfth day, coincident with the cessation of oozing, and did not completely recede for several weeks.

Infective Sinus Thrombosis.—It has been pointed out that a septic thrombosis of the extracranial veins may pass by way of the

emissary channels into the diploëtic or meningeal vessels and finally involve one of the intracranial sinuses—always with disastrous symptoms. The original infection need not appear to be a serious one. For example, a small pustule on the forehead may lead to a thrombosis of the supra-orbital vein and the process may spread to the cavernous sinus and a rapidly fatal pyemia result. However, with the modern treatment of wounds septic sinus thrombosis secondary to extracranial infections has greatly lessened in frequency.

There remain, nevertheless, some forms of chronic suppuration—namely, those which occur in the middle ear and accessory sinuses of the nose—which, for various reasons, continue to be a frequent forerunner of sinus thrombosis. Briefly, these reasons are (1) the anatomical proximity of the sphenoidal cavities to the cavernous sinuses and of the antrum and mastoid cells to the sigmoid sinuses; and (2) the indifference with which long-standing suppurative processes in these cavities are regarded by laity and profession alike.

Of the Sigmoid Sinus.—Chronic otitis media is the cause of sinus phlebitis in two-thirds of all cases (Körner), and the process is said to occur much more frequently on the right side. When the mastoid cells and antrum have been involved in a long-standing suppuration, so that the thin shell of bone separating them from the sigmoid sinus has become eroded, an increase in the activity of the process, especially if there is any obstruction to free discharge, may lead to intracranial complications. The likelihood of this depends on anatomical conditions,—on the size, position, and structure of the mastoid cells and their relation to the sinus; on the persistence of sutures or presence of bone defects; and on the peculiar distribution of the blood supply. If an abscess forms the pus may find its way out to the external surface by various routes; under the deep tissues of the neck or under the temporal muscle (Fig. 3, p. 23); it may break through under the dura and lead to an extradural abscess or to meningitis, or even to a cerebral or cerebellar abscess; it may extend to the sinus either by direct continuity of the abscess cavity and the sinus wall, or by the spread of a septic phlebitis from some small vein which empties into the sigmoid sinus or jugular bulb.

The disease in the mastoid cells may have existed up to the time when the sinus becomes involved in a subacute or chronic form. Destruction of the lining mucous membrane finally occurs, with erosion and necrosis of the bones, and in the bone defect thus formed infective granulations spring up under the dura. The sinus walls become invaded, the endothelium is destroyed, and a local thrombosis occurs. This thrombotic process advances until the vessel becomes occluded, and it fortunately tends to keep ahead of the pyogenic solution of the clot which almost invariably follows. Hence, there may be a large fluid abscess in the sinus, completely shut off from the general circulation on each side by advancing thrombotic plugs which as yet have not become broken down.

From the sigmoid, the process may spread to the sagittal sinus or

down the jugular into the neck, in rare instances as far as the subclavian. The petrosal sinus may be the one primarily involved, especially after perforation of the tegmen tympani, and the thrombus may extend forward to the cavernous sinus or backward and involve the sigmoid secondarily.

In addition to the external evidences of trouble furnished by the discharging ear and mastoid tenderness, possibly with some local swelling and edema, general symptoms are apt to appear. They are partly mechanical from circulatory stasis, partly toxic in consequence of the infection. There may be an initial chill; headache, whether general or local, is apt to be severe; nausea, dizziness, and vomiting are frequent; fever, which may be high and which is apt to show marked remissions, with rapid pulse, sweating, and leukocytosis, is commonly seen. In case the process spreads and the thrombus breaks down, particles may be swept into the general circulation with the typical manifestations of pyemia. The metastatic abscesses are particularly apt to occur on the lungs (Hessler). Unless meningitis or cerebral abscess complicates sinus phlebitis, or the process becomes sufficiently extensive to seriously compromise the intracranial venous circulation, the patient's mind may remain practically clear to the end. According to the seat of the more serious complications, however, we have typhoidal, pulmonary, or meningeal types of the disease.

In milder cases the process may subside without having given any definite evidence of its presence. Often not until the sinus has been exposed and sometimes not until it has been punctured is it possible to establish the presence or absence of the lesion. At times, however, we may surmise the existence of phlebitis from external signs alone: for the usual tenderness and edema over the mastoid protuberance may become accentuated, owing to involvement of the emissary channels to the scalp, even leading to an external abscess. There may be tenderness along the course of the internal jugular vein, particularly in its upper third, where, indeed, the thrombosed vessel may be palpable—a condition not to be looked for too energetically—and the patient is apt to hold the head tilted toward the diseased side to relieve pressure upon the vessel. A further sign is the not uncommon implication of the cerebral nerves which accompany the vein through the jugular foramen, and even the hypoglossal through the anterior condyloid foramen has been affected. Hoarseness, dysphagia, dyspnea, or brachycardia may result, or symptoms of weakness in the muscles innervated by the spinal accessory.

Of the Cavernous Sinus.—Here thrombosis occurs usually as the result of neglected infections in the territory of the orbit and brow. More rarely it is the result of a chronic suppurative process in the sphenoidal cells, which by direct extension through their necrosed walls finally involves the cavernous, just as chronic mastoid disease extends to the sigmoid sinus. St. Clair Thomson has recently called particular attention to this, and in 1902 Dwight and Germain collected 178 cases from the literature.

Being surgically less approachable than is the sigmoid, cavernous sinus phlebitis is a more serious lesion. Its general symptoms and pyemic sequels are naturally similar to those presented by sigmoid involvement. Its local manifestations, however, differ. Leaving aside the element of infection they are the same as in the still more rare traumatic and non-septic forms; namely, a high grade of exophthalmos, chemosis, a profound degree of choked disk with extensive retinal hemorrhages, and congestion of the external veins radiating to the orbit. In addition, lesions of the nerves are to be expected—as palsy of the oculomotor group — so that the protruding globe with its dilated pupil is immovable; or involvement of the trigeminus, causing hyperesthesia, particularly in its ophthalmic distribution, and oftentimes herpes. Septic thrombosis of the cavernous sinus rarely remains local, but through the circular sinus the vessel on the opposite side becomes affected and a double exophthalmos results (Fig. 79). Death from pyemia or meningitis is almost a certain outcome.

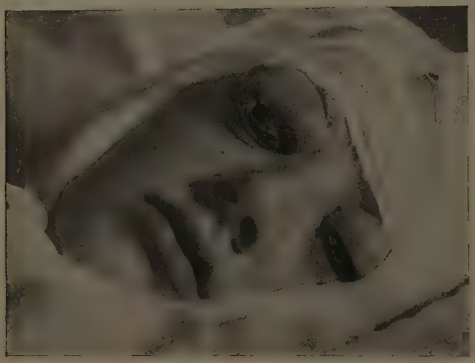

FIG. 79.—CHARACTERISTIC APPEARANCE RESULTING FROM DOUBLE SEPTIC CAVERNOUS SINUS PHLEBITIS. (Kindness of Mr. St. Clair Thomson.)

Of the Longitudinal Sinus.—A septic phlebitis here is usually the result of cranial osteomyelitis from infected wounds, contusions, or erysipelas of the scalp. It is not associated with any especial pathognomonic symptoms beyond those of general intracranial venous stasis. Bleeding from the nose is considered to be a common sequel. When secondary to sigmoid and lateral sinus thrombosis the torcular has necessarily become occluded, and the resulting symptoms are almost as serious as thrombosis of both lateral sinuses—a condition which results in such circulatory stasis that death, with compression symptoms, rapidly follows.

The *diagnosis* may be comparatively simple in the presence of such significant local symptoms as infiltration or tenderness over the jugular vein, pain, tenderness and edema at the posterior border of the mastoid, sudden exophthalmos and chemosis, paralysis of nerves, and the like. Unfortunately cases need not present these local signs until a late stage, and if the original source of the trouble in the ear, nasal sinuses, or in a superficial wound has been overlooked, the case may present general symptoms which so obscure the local ones that typhoid fever, tuberculosis, septic endocarditis, malaria, or septic fevers of other sorts may be suspected. Indeed, symptoms of meningitis or cerebral abscess may be the first evidence of an illness which has originated in some cranial process. If an otorrhea has been found during the course of the exami-

nation it is sometimes difficult to tell, without sufficient history, whether it was primary or only an incidental complication. Often through the process of elimination alone can we exclude these possible sources of the infection—by the absence of a Widal reaction, of the malarial plasmodium, of leukocytosis, of a cardiac lesion, etc. We must always bear in mind and exclude, if possible, an otitic infection in every case of septic fever.

The *prognosis* hinges on the diagnostic acuteness of the attendant and prompt surgical intervention; for an early evacuation of the infected clot will alone serve in most cases to ward off fatal complications. When untreated the disease almost invariably leads to meningeal or cerebral infection or general pyemia, on the rapidity of whose progress its duration depends. Two to six weeks is given as the average duration, though it may become a long-drawn-out battle of the individual against the septic intoxication. Rare cases are recorded of undoubted septic sinus phlebitis in which, unaided, the process has recovered, either by absorption or spontaneous external discharge of the phlebitic abscess.

Treatment.—In every case of suspected sigmoid phlebitis the mastoid cells and antrum should be opened and cleaned out and the sinus laid bare. This is usually done with a mallet and gouge, a method fraught with somewhat more danger than when a large Doyen burr is used. Oftentimes one may recognize the presence of phlebitis by observation alone of the exposed walls of the sinus, but if in doubt a hypodermic needle may be inserted and some of the contents aspirated. If the sinus is found occluded it should be freely opened and the softened clot removed, care being taken not to break down by too energetic measures the outlying thrombotic plugs. If the symptoms do not quickly subside, or if there is at the same time unmistakable evidence of intracranial complication, the dura must be opened and local meningitis or cerebral or cerebellar abscess sought for (p. 174). If the bulb and upper part of the jugular in the neck are involved it is advisable, in order to lessen the likelihood of infected particles being swept into the general circulation, to ligate the vessel low down in the neck, after which it may be opened and the infected clot safely washed out by a through-and-through irrigation to the open sinus in the mastoid region. This method was advocated by Zanfel in 1880, and brilliant results have followed its adoption. In 1896 Hessler reported 59 per cent. of recoveries in 88 cases, while Macewen records almost 80 per cent. of recoveries in his 28 cases; and the rules laid down by him are generally followed. It is to be remembered that the lateral sinus should be opened in all cases, an operation upon the jugular alone being insufficient.

Only a few recorded attempts have been made to approach and drain the cavernous sinus. Immediate enucleation of the eyeball followed by thorough scraping, disinfection, and drainage from the sphenoidal fissure has been recommended. The sinus may be approached directly through the middle cranial fossa by the temporal route under the dura. This I have carried out in one desperate case which resulted fatally.

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Injuries of the Meningeal Vessels.—The sinuses, as well as the pachymeningeal arteries, are liable to traumatic injury. Hemorrhage results, whether between bone and dura, dura and arachnoid, or in the arachnoid spaces. The sinuses may be lacerated, as we have seen, in consequence of parietal overlap during parturition; they may be torn by fragments of bone in cases of comminuted fracture; they may be injured during operation. In the first the injury occurs usually at the sides of the sinoidal wedge and hemorrhage is subdural; in the second it is usually the back or top of the wedge which is injured, and unless the tear is so extensive as to involve the sides of the sinus the bleeding may be entirely external to the dura.

Injuries of the meningeal artery leading to the so-called "meningeal apoplexy" usually result from linear fractures of the skull and lead to compression, subjects fully dealt with in other sections. The same is true of lesions of the leptomeningeal vessels and larger arteries during their intracranial course. One particular effect may be considered here.

Arteriovenous Aneurysm with Pulsating Exophthalmos.—This form of aneurysm by anastomosis, due to a communication between the cavernous sinus and internal carotid where they are in close juxtaposition alongside the sella turcica, is usually (70 per cent. of cases) of traumatic origin. It is commonly due to bursting fractures of the base, and in case the fissures enter the middle cranial fossa and pass under the vessels, closely held in their common dural sheath, they may be so injured that an anastomosis results. The lesion may be bilateral. The communication may be immediate or may take place slowly, so that it may be days or weeks after the injury before the evidences of reversed circulation with high pressure in the veins appear.

The *symptoms*, characteristic of all such anastomoses, are considerably modified in this situation. Most striking of all is the protrusion of the eyeball (Fig. 80). The globe is dislocated outward by the intra-orbital pressure and usually tilted so that diplopia results: it may be visibly pulsating and if not, pressure against it will bring out the pulsation. There may be impairment of sight, even blindness. A loud systolic (occasionally a continuous) bruit can be heard on auscultation almost anywhere over the head, and the roaring sound is distressingly audible to the patient, who in consequence may be quite deaf to ordinary external sounds. The reversal of the blood flow leads to a great dilatation and thickening (arterialization) of the veins radiating from the orbit, and those in the lids, conjunctiva, and fundus are

likewise dilated. Visible pulsation may be present in them. Headaches are common.

The condition may last for years and in a few isolated cases spontaneous recovery has taken place. Hemorrhages, sometimes profuse, occasionally fatal, may occur from the Schneiderian membrane. It is to be noted that a traumatic sacculated aneurysm of the carotid can give rise to practically the same symptoms.

FIG. 80.—PULSATING EXOPHTHALMOS FROM ARTERIOVENOUS ANEURYSM.

Showing lack of parallelism in eyes (patient looking to right); also ease of dislocation of globe on slight pressure against outer canthus.

The *treatment* is limited either to compression or ligation of the carotid. Occasional cures have been recorded after simple long-continued obliteration of the carotid pulse by pressure, but a greater number have followed ligation, preferably of the internal carotid. There are certain dangers from this procedure due to cerebral anemia and softening, particularly in the very cases in which most could be expected from the operation—namely, when the Willisian anastomosis is not free. Considerable improvement may be expected, even though complete subsidence of the process does not occur. A successive ligation of both carotids has been practised in a few cases, with a high mortality; and this has also attended the efforts to treat the condition locally by ligation of the orbital veins (Dollinger; Woodward) in the hope of producing an obliterative thrombosis.

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INFLAMMATION OF THE CEREBRAL ENVELOPES AND EPENDYMA.

Pachymeningitis.—Pachymeningitis externa accompanies osteomyelitis and is naturally a frequent precursor of inflammations of the inner dural surface as well as of the leptomeninges. Such an inflammation, when, for example, it is secondary to chronic suppuration of the middle ear, may go on to a local abscess formation, which, if promptly evacuated, may remain extradural. Owing to the sensitivity

of the dura these processes are usually associated with distressing headache. In the syphilitic osteomyelitis there may be found a great thickening of the inner table and a large extradural collection of pus. Chronic inflammatory processes leading to an almost inseparable attachment of dura and bone are not infrequently found.

Pachymeningitis hæmorrhagica interna, characterized by the formation of an easily detached membrane on the inner surface of the dura, was first carefully described by Heschl (1855) and Virchow (1856). It has been found in badly nourished children; in patients suffering from profound anemia; and it is especially frequent in the insane. In 1185 autopsies at the Government Hospital for the Insane, Blackburn found 197 cases of true dural neomembrane.

Morbid Anatomy.—There has been some difference of opinion in regard to the formation of the membrane, Virchow's view being that it preceded hemorrhage. There may be found a vascular membrane of extreme delicacy, easily separable from the dura, which has been presumed to represent an inflammatory exudate undergoing organization, and which under certain circumstances may lead to vascular extravasation. On the other hand, a thin subdural hemorrhage may be found alone, without trace of membrane. However this may be, repeated extravasations occur, leading at times to the presence of laminated clots from 3 to 5 mm. in thickness. Cysts may occur within this membrane. Atrophy of the convolutions is usually associated with the process, for it is common in paralytic or senile dementia, in phthisis, and other cachectic conditions.

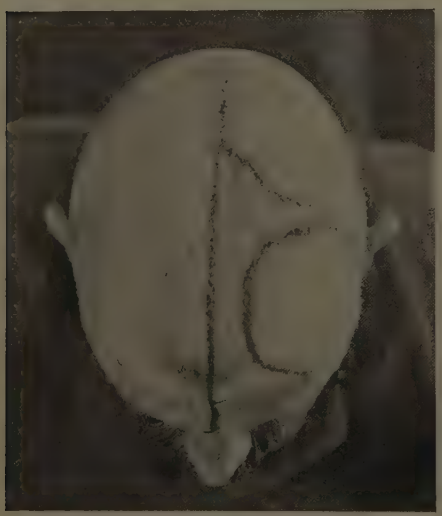

FIG. 81.—PACHYMENINGITIS EXTERNA HEMORRHAGICA AFTER OPERATION.
Showing situation of resection in relation to sagittal and Rolandic lines.

The *symptoms* are indifferent and may be merely those of progressive dementia, though with extensive extravasations signs of intracranial pressure may occur. Headache may be a prominent symptom; also convulsive seizures.

Treatment.—There is no medical, and possibly no surgical, treatment for this condition. Munro, however, has called attention to certain experiences which he has had, and I have once inadvertently exposed this lesion myself at operation.

A patient with a luetic history had been suffering from severe headaches, occasional right-sided convulsions without loss of consciousness, and obscure mental symptoms, since the reception of a cranial injury some months previously. A

diagnosis of cortical tumor or gumma involving the left frontal lobe was made and an exploratory craniotomy performed. Underneath the dura a neomembrane 2 or 3 cm. in thickness was found. It was so slightly adherent that it readily peeled away in large sheets; and not only from the bone-flap itself, but also for some distance beyond the confines of the opening was it possible to strip off the membrane. Its removal left a smooth, shiny, normal appearing dura, and it is difficult to see how the process could have originated as a dural inflammation. The frontal lobe was considerably atrophied; the leptomeninges thickened, and there was an increase of fluid (*hydrops ex vacuo*). Though evidently a case of progressive dementia, the patient appears to have been benefited by this operation, performed two years ago. His headaches have ceased and there has been no return of the convulsions (Fig. 81).

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Leptomeningitis.—An acute inflammation of the pia-arachnoid may occur as a primary and specific malady, or as one secondary to a great variety of local or general infections. In its primary form the process is apt to become generalized at an early stage—the so-called posterior basic meningitis possibly being an exception: in many of the secondary forms it tends to remain localized, and this is particularly true in those conditions which are of chief surgical moment—the traumatic, otitic, and rhinitic cases. The exudate may be thickly purulent with an abundant bacterial content, or it may be serous and sterile. There are many forms which affect infants particularly; others more common in adults. There are forms which are rapidly fatal in a few hours; others which may be protracted for months.

We thus see that the clinical picture may be a very complex one, and it is best to briefly limit the description of the disease to the more characteristic type of primary infection, namely to—

Infectious Cerebrospinal Fever.—This specific infection, due to the *Diplococcus intracellularis* (Weichselbaum), occurs either in epidemic form or, as a sporadic malady, crops out from time to time in isolated instances over the entire country. It is probable that the form of meningitis described by Barlow as "posterior basic" is produced by the same organism (Still), although the exudate is limited in these cases to the under surface of the hind-brain and cerebellum, as the name indicates. This form of the disease is most frequent in infants, though no age is exempt.

Beyond the intense injection of the brain and cord there may be, in uncomplicated cases, no characteristic changes except those observed in the meninges themselves. The exudate, seropurulent at first, becomes thicker and finally plasters the cord, the brain stem, the cerebral nerves, and, when advanced, even the cortex with a dense fibrino-purulent layer. In case it occludes the foramina about the fourth

ventricle, obstructive hydrocephalus results. Patches of acute encephalitis are not infrequent.

The disease shows a kaleidoscopic clinical picture. There is a fulminating type, in which, after a sudden onset, with rigor, headache, spasms, and somnolence, death may supervene within the first twenty-four hours. Even in the ordinary forms the symptoms usually set in suddenly with headache, chill, and vomiting. There is photophobia, irritability, and restlessness, severe pains in the back and legs, accompanied with hyperesthesia, muscular tremors, or spasmodic movements. Convulsions are rare, except in the infantile cases. Paralyses of cranial nerves, particularly of the ocular nerves, are common. Herpes due to trigeminal involvement is frequently seen. Stiffness of the neck is an early symptom and with it retraction, which, in the infantile basilar forms, may become so marked that occiput and heels meet (Fig. 82). The temperature is irregular, but rarely high except at the terminal stages. The pulse is variable; it may at first be full and strong; it may become slow, in common with other pressure symptoms, when an acute hydrocephalus develops; it is usually rapid and irregular. A hyperleukocytosis is usual. The respiration may become affected, either from pulmonary involvement or from pressure; Cheyne-Stokes respiration is common in the terminal stages. Choked disk may occur, especially when ventricular hydrops develops; there may also be a true optic neuritis from extension of inflammatory products along the optic sheath.

FIG. 82.—UNCONSCIOUS CHILD SUPPORTED BY NAPE OF NECK TO SHOW EXTREME DEGREE OF RIGIDITY AND HYPEREXTENSION.

Note pressure decubitus of scalp. (Service of L. F. Barker.)

The course is most variable. Death may occur in a few hours after onset or long after the acute process has subsided, in consequence of intracranial complications. It is said that more than half of the fatalities occur within the first five days. Convalescence at the best is apt to be tedious and long drawn out.

The complications, both immediate and late, are numerous. Cranial paralyses, patches of encephalitis, thrombosis of cerebral vessels, etc., may lead to a variety of symptoms indicating either peripheral or central palsies. The complications of chief surgical interest, aside from the acute obstructive hydrocephalus, are epilepsy, due to the persistence

of cortico-meningeal adhesions, and a chronic persistence of the ventricular dilatation.

The *diagnosis* should not be difficult, although pneumonia or typhoid may at times have a similar acute "meningeal" onset. Even should the general symptoms be obscure, a lumbar puncture usually enables us to make an infallible diagnosis.

Though Flexner's reports encourage the hope that we may come to possess an antidiplococcal serum, we heretofore have had no therapeutic agent that is in any sense a specific for this disease, the mortality of which is said to fluctuate in various epidemics between 20 and 75 per cent. The medical treatment must be purely symptomatic and supporting.

Surgical Treatment.—After the introduction by Quincke of lumbar puncture as a diagnostic measure it became apparent that the withdrawal of the fluid proved symptomatically beneficial as well as diagnostically helpful. It consequently has grown to be a common practice to repeat these punctures for therapeutic purposes, but all who have done so have learned that after the exudate becomes fibrinous and enmeshed in the subarachnoid spaces, fluid can no longer be withdrawn through the needle, and this at the very stage of the disease when the most pronounced pressure symptoms usually occur. Were the arachnoid spaces open ones and unbroken by a fibrous meshwork—even as open as the subdural space—it is probable that cerebrospinal meningitis would be as amenable to surgical measures as is a suppurative process in pericardium, pleura, or peritoneum. But even as it is, operative measures with permanent drainage have held out considerable promise of benefit. The earlier operations were done in the lumbar region; one of them I performed in 1898 on a critically ill patient in Osler's wards who recovered. Subsequent attempts were unsuccessful, as the patients died ultimately from obstructive hydrocephalus in spite of the lumbar opening. I doubt not that a suboccipital drainage of the cisternæ, as suggested by Ballance, would be far preferable, though my experience with this method has been limited to cases of meningitis suppurativa.

The meningeal infection in itself may be regarded as a self-limited disease, and leaving out of consideration pulmonary and other unusual complications which may prove fatal, the cause of death is usually purely mechanical, due to the cerebral pressure from ventricular obstruction. When this condition supervenes, lumbar puncture is no longer capable of emptying the ventricle and ceases to be helpful. In these stages, therefore, we must resort to single or repeated ventricular punctures which will give marked symptomatic relief, and though I have never as yet secured a recovery thereby, I doubt not but that, with the confidence of the physician, earlier attempts may in the future meet with greater success: for if acute pressure symptoms can be warded off in this way sufficient time may be gained in order to allow the activity of the meningeal infection to susbide, and with resorption of the fibrinous exudate the foramina of exit for the fluid from the ventricles may reopen.

The method is simple. General narcosis is not necessary—indeed, a local anesthetic need not be—as the patient usually is unconscious. I prefer the superior route (Kocher's), as it is somewhat less of an operation than that conducted through the temporal muscle. The cranial opening is made with a large burr which leaves a cup-shaped depression with a sufficient exposure of dura to allow a small opening to be made, in order to assure oneself of the absence of an underlying cortical vein, puncture of which might lead to considerable subdural hemorrhage. The curved superficial incision should have been made slightly to one side of the proposed trephine opening, so that subsequent punctures can be made directly through the scalp. It is inadvisable to move these patients, and the operation, which is not much more elaborate than is a lumbar puncture, should be done in the ward in the patient's bed.

Certain late complications which may be of surgical import can occur in patients who, after a tedious convalescence, have recovered from the infection. Chief among them are epilepsy and chronic ventricular hydrops. The former is due to adhesions and rarely occurs except in patients in whom the exudate has extended up over the hemispheres; the latter is due to a partial absorption only of the exudate about the fourth ventricle.

I have had one notable experience with a small boy in whom both of these complications existed. After a desperate and prolonged attack of cerebrospinal fever he recovered from the infection, but was left epileptic and mentally deficient. A bilateral exploratory craniotomy was performed, the abundant fine adhesions between arachnoid and pia were broken down, and by a combined ventricular and lumbar puncture the excess of fluid was evacuated. Apparently the procedure served to re-establish channels through which the fluids could properly circulate, for there has been no return whatsoever of the fits or disturbing pressure symptoms, and the child has remained perfectly well for two years. I believe this combination of ventricular and lumbar puncture with an open skull, in cases of acquired obstructive hydrocephalus, may bring a new principle into the treatment of these conditions.

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There remain certain pyogenic forms of secondary meningeal infection (*Leptomeningitis suppurativa*), which deserve separate mention, although their symptomatology and morbid anatomy do not, and their

treatment should not differ greatly from that of cerebrospinal fever. And the same may be said of the various forms of meningitis, serous or purulent, which cannot be considered here—those due to sunstroke, to alcohol and other intoxications, those which are the terminal event in many infectious diseases, etc.

Traumatic meningitis is the most common form of all and is particularly apt to follow penetrating wounds or compound fractures of the skull, and too frequently, alas, unclean operative measures. It may occur even after a cranial injury not associated with demonstrable fracture, due probably to a hematogenous infection of a meningeal or cortical extravasation, and it is a frequent sequel of fractures which open into the accessory sinuses of the nasal passages. It must be remembered also that a tuberculous meningitis is not infrequently attributable to a preceding cranial injury.

Meningitis Secondary to Neighboring Disease.—Chronic suppurations of otitic, rhinitic, or ophthalmic (panophthalmitis) origin are a most prolific source of meningeal infection, and writers formerly were inclined to attribute many cases to erysipelas or furunculosis of the scalp.

It may be difficult in many of these conditions to determine whether the complicating intracranial symptoms are due to sinus thrombosis, to meningitis, or to abscess, the differential points of which are enumerated elsewhere. The infection may occur either by direct extension of the inflammatory process or as a consequence of the passage of bacteria to the meninges by way of a suppurative phlebitis or lymphangitis. A form of "serous meningitis" which does not go on to suppuration is very commonly seen in the otitic cases. New growths of various sorts, as well as tuberculosis or syphilis of the skull, may also lead to secondary meningitis in consequence of cranial caries or necrosis.

In the pyogenic cases the usual organisms are the *Streptococcus*, the *Staphylococcus aureus*, less commonly the *albus* and *citreus*, and rarely the *Bacillus pyogenes fœtidus*. The *Pneumococcus* is found as the invading organism not only in meningitis secondary to pneumonia, but in many cases of basal fracture which open the nasal cavities, and also occasionally as the primary factor in sporadic cerebrospinal meningitis. Infrequently the *Bacillus typhosus*, *Bacillus coli communis*, Pfeiffer's bacillus, the *Bacillus aërogenes*, the *Bacillus anthracis*, and others have been found.

The distribution of the infection, as well as the rapidity of its spread, varies greatly. The differences are due to the manner of onset, whether it be hematogenous or merely the result of direct extension from a suppurative focus, but in any case the infection usually becomes diffused through the medium of the circulating cerebrospinal fluid. Hence a lumbar puncture, even in cases of primary cranial infection, will quickly show an excess of leukocytes and possibly bacteria. There are some notable exceptions to this rule, particularly in the posterior basic form of meningitis, in which, even when the process is advanced, the lumbar subarachnoid fluid may remain sterile.

The prognosis in these secondary infections is, on the whole, less favorable than in cerebrospinal fever, bad though the latter is. In certain cases the infection is of a fulminating type, particularly when the streptococcus is the invading organism. In others its spread is less rapid and the focus of disease may remain circumscribed for some time—a factor which favors surgical intervention in secondary meningitis, provided the primary seat of infection is known and is accessible.

Treatment.—Oftentimes by a thorough exposure and drainage of the area of infection the process may be checked. When, however, it has become so advanced that the basal meninges are involved, the treatment does not differ greatly from that of cerebrospinal fever. The fact that radical measures, first suggested by S. W. Gross in 1873, have not been more generally attempted is but an indication of their difficulties. Only in the hands of certain individuals who have paid especial attention to the subject have the results been encouraging. Macewen in his comprehensive work cites 12 cases of infectious circumscribed leptomeningitis of otogenous origin which were cured by operation. Only isolated cases, however, have been reported of surgical success in combating widespread meningeal infections (Hinsburg, Witzel, Poirier, Lenhartz, etc.). In some of these cases the lumbar meninges alone have been opened and a permanent drainage established there. In others the attack has been made at the arachnoid cisternæ underlying the hind-brain, and inasmuch as the disturbances of pressure arise through complications near this region it is natural to suppose that suboccipital operations and drainage offer a better prospect of recovery than those which are undertaken at a distance.

Except in the fulminating types of meningitis, in which death is due to a general septicemia, the fatalities are usually due to the pressure symptoms of an obstructing hydrocephalus, just as in cases of cerebrospinal fever already described. As the result of his experimental observations, Leonard Hill suggested that by a combined cranial and spinal opening it might be possible to irrigate through and through the meningeal spaces, and thus to wash away products of infection. As a matter of practice, however, this has been found impossible, due partly to the tension of the ventricular hydrops; partly to the fact that an attempt to introduce fluid by the spinal route causes the brain to float up against the cranial opening in such a way that the latter becomes plugged and fluid cannot escape; and due also to the fact that it is necessary, particularly in the presence of meningeal disease, to force the fluid with considerable tension before it will pass through the meningeal spaces—thus the irrigating fluid itself may add a further danger to pressure symptoms already present. The method of through-and-through irrigation has had to be abandoned.

Simple drainage, particularly from those spaces which are not broken up by a fibrous meshwork, is much more efficacious than an attempted irrigation. Kümmel has recently recorded a successful case of suboccipital drainage in secondary pyogenic meningitis following basal fracture. A large trephine opening (or preferably bilateral ones) should be made

in the suboccipital region through an intermuscular approach. On opening the dura a blunt instrument should be passed underneath the cerebellum inward and forward, until it opens the cisternæ on each side. Drainage should then be encouraged by the introduction of a soft tube or wicks of rubber protective.

The complication of internal hydrocephalus must be met, as in ventricular obstruction from other causes, by puncture. This, if repeated, may serve to ward off compression symptoms long enough to enable the individual to combat the active infection, and the obstructing exudate may become absorbed during the time thus gained.

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Serous amicrobic meningitis, a form of acute non-tuberculous hydrocephalus, was described in 1844 by Barthez and Rilliet. Billroth, in 1869, designated the condition "meningitis serosa." Not, however, until 1887 did Eichhorst clearly demonstrate the fact that these cases not only arise acutely, but remain serous and non-purulent throughout their entire course. Quincke, in 1893, as the result of lumbar punctures, succeeded in giving a more exact description of the clinical picture, so that the condition has justly become associated with his name.

It presumably is far from being a rare infection. Doubtless the meningeal symptoms which appear in the course of many acute infectious diseases—in typhoid (Schultze), in pneumonia, in influenza, etc.—are often due to meningitis serosa. In these cases it is of toxic origin and not due to bacterial invasion. It may accompany acute alcoholism. It occurs with especial frequence as a complication of acute otitis media, when it may closely simulate suppurative meningitis or abscess. Traumatism is also an important etiological factor, and one not infrequently encounters during operations for supposed intracranial injuries no lesion other than an excessive collection of cerebrospinal fluid in the subarachnoid spaces, which has led to pressure phenomena. These cases, which are often cured or greatly benefited by a craniotomy, might, as Quincke has shown, be treated with equal success by a withdrawal of the fluid from the lumbar region. The chief collection of fluid may be either over the convexity or in the ventricles.

Beyond some hyperemia of the leptomeninges and the excess of fluid there is no characteristic pathological change. Hence, a post-mortem examination usually fails to disclose the evanescent lesion, so easily demonstrated by operative measures.

The *symptoms* are often those of an acute febrile meningeal infection.

Generally speaking they are headache, hyperesthesia of the body and limbs, high temperature, leukocytosis, slow pulse, vomiting, mental dulness, stiffness of the neck, and possibly a choked disk; frequently ocular and other cranial nerve palsies occur. On lumbar puncture the fluid is clear, of high pressure, and large in amount. It contains only a few lymphocytes, gives an albumin reaction, is sterile on the usual culture media, and shows no pathogenicity to animals. In the chronic cases the condition is usually mistaken for a brain tumor.

The *prognosis* is favorable, except in those instances in which an acute internal hydrocephalus has passed into a chronic condition, due to some thickening of ependyma and leptomeninges. In such cases recurrent headache with other signs of pressure may reappear from time to time over long periods.

The *treatment*, beyond general symptomatic measures, is purely operative, and withdrawal of the fluid by a lumbar puncture may cure the condition after one or more tappings. Occasionally a craniotomy may be necessary; and in obstructive hydrocephalus, ventricular aspiration. A subtemporal decompressive craniectomy is practically curative, though such a radical measure is not necessary for all cases.

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Ependymitis, a chronic inflammation of the ependymal lining of the cerebral ventricles, apart from any known association with an infectious meningitis, seemingly occurs as a specific malady, although few cases have been reported from their clinical aspects, and the condition is usually recognized from its post-mortem appearances alone—namely, a characteristic granular thickening of the ependymal surface. Indeed, inflammations of the ependyma and of the choroid plexus, which doubtless play a large part in conditions of hydrocephalus, have received far less attention than they deserve, for probably here lies the key to a better understanding of the physiology of the cerebrospinal fluid circulation, and consequently of the circulatory disturbances from which it may suffer.

The process, whatever its nature may be, whether inflammatory or not, often leads to an occlusion of one or another of the narrowings of the ventricular channels, so that symptoms of acute hydrocephalus, with its familiar pressure phenomena, dominate the clinical picture. In some cases one ventricle alone may become occluded.

Thus, a patient some months after an acute attack of so-called "brain fever," presented symptoms that were supposed to be those of tumor—profound headache of varying intensity, located on the left side; choked disk, more pronounced in the left eye; attacks of vomiting, aphasia, and weakness of the body musculature on the right side. A simple decompressive operation was performed, unfortunately without aspiration of the ventricle. The patient's symptoms were not appreciably altered, and some weeks later he died from bulbar paralysis due to pressure. At the autopsy a dilatation of the left ventricle alone was found. The choroid plexus appeared hypertrophic and greatly enlarged. The ependyma was studded with sago-like granulations and the left foramen of Munro was occluded. The ventricular linings elsewhere were perfectly normal in appearance and there was no trace of thickening of the basal meninges suggestive of an earlier meningeal infection.

The process, doubtless, often bears some relation to pre-existing meningeal disturbances, whether infective or not. Thus, chronic acquired hydrocephalus of the adult, giving intermittent symptoms and showing granular ependymal thickenings, may represent the chronic stage of serous meningitis of the ventricular form. In Fig. 113, p. 213, is shown a photograph of the brain of a patient who died from apoplexy and in whom an unsuspected granular ependymitis with ventricular dilatation was found.

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Tuberculous meningitis is especially common in children. It is almost invariably fatal, owing presumably to the acute ventricular hydrops of its later stages; some undoubted instances of recovery have been recorded, but they are exceptionally rare. The disease is probably always secondary to some focus elsewhere in the body, although this primary lesion may escape minute postmortem search.

The meninges at the base, about the interpeduncular space, are chiefly involved, and the slightly turbid cerebrospinal fluid, together with the tubercles scattered over the meninges and ependyma, make the pathological lesion quite distinct from that of cerebrospinal fever proper. There may, however, be considerable fibrinous exudate, which may surround the nerves and extend into the ventricle and up along the Sylvian fissure over the hemisphere. Patches of meningoencephalitis also are not uncommon.

The clinical picture here is also a complex one, and differs from acute cerebrospinal fever, chiefly in its less abrupt onset and longer duration. In the final stage of paralysis due to ventricular dilatation the child may remain in a semicomatose condition, with muscular rigidity, marked cervical retraction, choked disk, cerebral nerve paralyses, and a normal or subnormal temperature for days. There are, however, acute forms of tuberculous meningitis which follow a course closely akin to the diplococcal form.

The *diagnosis* is rarely difficult, especially if there is a demonstrable

focus of tuberculosis elsewhere. An unequivocal diagnosis can be made by the withdrawal of fluid from the lumbar meninges, which, although containing an excess of mononuclear lymphocytes, proves sterile on ordinary media and contains a few tubercle bacilli, frequent search for which should be made in doubtful cases.

The *treatment* does not differ from that of the acute endemic form. The mechanical disturbances from pressure should be met by lumbar puncture, and when hydrocephalus supervenes, by ventricular puncture.

Syphilitic Meningitis.—Of the meningeal complications of syphilis 48 per cent. are said to appear within the first three years after the primary infection, the percentage diminishing with each succeeding year. The process may be represented either by solitary or multiple circumscribed new growths of granulation tissue—gummatous tumor (Virchow), syphiloma (Wagner)—or, on the other hand, by a diffuse process. Although the most characteristic forms of the disease arise in the leptomeninges, they can become secondarily involved in consequence of a syphilitic process originating in the bones or periosteum. Pachymeningitis hæmorrhagica, already considered, is supposedly of a remote luetic origin.

The favorite seat of cerebral lues, either of dural or cranial origin, is the frontal region of the vault. When, on the other hand, it occurs primarily in the arachnoid or subarachnoid tissue, the process is more commonly basal, often occupying the interpeduncular space. The cerebral nerves and cerebrum itself become secondarily involved. Thus, there is a definite form of syphilitic perineuritis in which the cerebral nerves become tumefied through a gummatous deposit about them, and when thus implicated peripheral palsies result. When the blood-vessels at the base have become involved central palsies occur, owing to vascular thrombosis and consequent cerebral softening. It is most exceptional for gummata to originate in the substance of the brain, though cases of this sort are recorded. The view has been expressed that even in these cases the point of origin lies in some intergyral infolding of the leptomeninges.

In addition to this diffuse or circumscribed gummatous growth which is characteristic of basal syphilis, we find, more often upon the surface of the hemispheres, another form of meningitis gummosa, in which the lesion is represented by one or more plaques of meningoencephalitis, in which the dura, leptomeninges, and cortex are bound together. Sclerotic or atrophic lesions of the cortex may follow the absorption of such a lesion.

The symptoms, as in all intracranial processes, depend on the character as well as on the situation of the lesion, and in intracranial syphilis may be most variable. Thus, we may have circumscribed tumors which may be single or multiple, a diffuse gummatous process, perineural deposits alone, vascular lesions which lead to cerebral softening, extensive plaques upon the cortex; and the affection, furthermore, may be either largely basal or largely confined to the convexity.

In *basilar syphilis* paroxysmal and nocturnal headaches, vomiting,

fainting spells, convulsions, somnolence, dulling of intelligence, choked disk, polydipsia, and polyuria are general symptoms which serve to evidence serious intracranial trouble. Cerebral nerve paralyses are very common, the motor nerves of the eye being most often affected. The trigeminus may be involved, leading to pain, hyperesthesia, etc., over its territory. There may also be facial paralysis and deafness. In case the cerebral vessels become inplicated, hemiplegia, hemianesthesia, hemianopsia, and aphasia may supervene.

One striking feature of closely studied cases is the variability in intensity of the symptoms, for they are apt to show remissions and exacerbations. In case the gummatous process has assumed a circumscribed form the symptoms are naturally of close kinship to those of tumor. An acute and widely distributed process, on the other hand, may be associated with pyrexia and closely resemble an acute basilar tuberculosis.

Syphilis of the convexity does not necessarily present a sharp contrast to the basilar form, inasmuch as the latter may extend up on to the external surface. There are, however, many instances of a purely circumscribed lesion upon the convexity. Headache, cortical epilepsy, local tenderness on percussion, with vomiting, fainting, and psychic disturbances are common symptoms. Optic neuritis is infrequent with this form of lesion, unless it assumes a tumor-like character. Its seat of predilection is in the central convolutions. Contralateral cortical paralyses of face or arm and aphasia are common symptoms. Not only may these local plaques of meningo-encephalitis occur, but there may be a diffuse and widespread lesion in which focal symptoms may not appear. In fact, owing to the possible multiplicity of lesions in cerebral syphilis due to gummatous meningitis, to syphilitic neuritis, to arteritis, to encephalitis, and to the combined cerebral and spinal lesions, it is impossible, in a short space, to fully portray its kaleidoscopic symptomatology.

Of chief value in **diagnosis** is the history of a primary infection or of its immediate sequels; next in importance is the examination of the patient for evidences of concomitant lesions, whether of inherited or of acquired syphilis. Should these fail, antisyphilitic treatment may establish the diagnosis in doubtful cases. Of importance also is the absence of stability in the symptoms, which "ebb and flow," as Oppenheim says. Barring these things, a diagnosis can rarely be made with absolute certainty, for precisely similar clinical phenomena may be produced by a variety of intracranial lesions which cause either general pressure symptoms or focal paralyses.

Though the basilar form of syphilitic meningitis is fairly characteristic, basal tumors, particularly those arising in the middle fossa from the cranium itself, give very similar symptoms. They are, however, apt to be progressive and to show no remissions, and complicating cerebral vascular symptoms are unusual. Tuberculous basilar meningitis may show close resemblance to certain of the acute luetic infections in the absence of scattered paralyses of the cerebral nerves.

Epilepsy, dementia paralytica, or hysteria may be closely simulated by cerebral lues.

In case they occur over silent areas of the cortex, so that no paralytic or irritative symptoms are elicited, and in the absence of pressure phenomena, local luetic foci upon the convexity may lead to no symptoms other than headache. When, however, there is a definite isolated syphiloma which encroaches upon the intracranial space, the symptoms need not differ from those of a meningeal or cortical neoplasm in the same situation and of the same size.

Of great value in differential diagnosis is a lumbar puncture, for lymphocytosis with a sterile fluid characterizes almost all forms of cerebrospinal syphilis. I believe that the spirochete has never been demonstrated in the cerebrospinal fluid in acquired syphilis.

Prognosis.—According to Fournier, one-third, and to Naunyn, one-half only of these cases may be cured by medicinal measures. In the rest the symptoms persist until death supervenes. Under treatment a large percentage of the curable cases show early improvement,—in the first week or two; or even in the first few days. Oppenheim is of opinion that patients untreated for the primary infection are more resistant to treatment on the occurrence of later complications. The prognosis is better in the cases of infection of the convexity than in the basilar forms, for in the latter vascular involvement and cerebral softening are common sequelæ.

Treatment.—The essential treatment of cerebral lues is a preventative one, which means a thorough medicinal course at the time of the inoculation. Should late intracranial symptoms appear, an immediate and active antiluetic régime, preferably with a combination of potassium iodid and mercury, should be instituted. In resistant cases mercury should be administered subcutaneously.

As has been said, a large number of cases show, under treatment, early signs of subsidence, but authorities differ in regard to the length of time in which this may be expected. It is a matter which is of no inconsiderable importance; for it must be remembered that the iodides and mercury, as Horsley pointed out in 1893, often serve temporarily to abate the symptoms of a sarcomatous growth, and consequently, as a diagnostic adjunct in syphilis, these therapeutic agents may be deceptive and lead to the fatal postponement of surgical measures in cases of cortical or meningeal tumor which are favorable for operation. The time which should be allowed for drug administration as a diagnostic measure should be brief—a matter of a few weeks; no longer than six, according to Horsley and Kocher. Although there are certain cases of lues in which there may be little or no abatement of symptoms even after a longer period than this, it is often inadvisable to prolong medicinal treatment, particularly in those patients who are suffering greatly from headaches and in whom optic atrophy is threatened. Allan Starr, however, advocates delay for at least three months and Oppenheim is of the opinion that even a longer time should be given.

In cases of undoubted cerebral lues subjective improvement at least

should be appreciated within the first two weeks after the institution of the treatment, even though paralyses may require a much longer time to clear up. If subjective improvement does not occur in this time under active treatment I would strongly favor, especially in cases in which a choked disk has occurred, an early decompressive craniotomy. This will, in the majority of cases, serve to put a stop to the subjective discomforts and to save the eyes from threatened blindness, and after the operation has been performed the treatment may be continued. A definite and localizable gumma of the convexity should, of course, be directly exposed.

Surgical intervention in cerebral syphilis is said to have been suggested by Rumpf, but Macewen first put it into active practice. Horsley and Gowers, in 1893, expressed the view that a gumma could not be totally absorbed by potassium iodid or mercury, and if in an approachable situation it was distinctly a surgical malady. It has since remained a question of dispute as to whether all gummatous processes are absorbable; many of them certainly are exceedingly resistant, even to the most active antiluetic régime. It is within the experience of many to have seen patients lose their vision during a prolonged treatment, in the course of which they have suffered greatly from cephalalgia. One cause of delay arises in the fact that these patients often attend an ambulatory clinic, even drifting from one clinic to another, with the consequent repetition of the six weeks necessary for the therapeutic test, so that months may elapse before surgical measures can be undertaken.

A considerable percentage of these cases should be treated on the principles laid down for a cerebral neoplasm; namely a period of active antiluetic therapy, followed, in case it does not bring early subjective relief or in case a choked disk develops, by prompt operative intervention. The operative attack should be directed toward the gumma itself if it is localizable and proves approachable; it should be simply decompressive if the lesion prove to be inaccessible or widespread. A number of most successful enucleations of hard, unabsorbable gummata have been recorded by Barton, Horsley, Krause, and others.

Stransky's excellent Sammelreferat on the subject should be consulted. He advises surgical intervention in case no positive results are obtained after two months of treatment. Operation is called for (1) by such cortical conditions as pachymeningitis externa, hydrocephalus internus, cerebral hemorrhage or luetic arteritis; (2) by the possibility of localizing the lesion on the cortex; (3) by symptomatic Jacksonian epilepsy; (4) by stationary conditions in which there is easy approach to an unabsorbed syphiloma.

I have seen a number of cases in which persistent cephalalgia has been quickly alleviated, together with a rapid subsidence of a choked disk, after a simple subtemporal decompression. This palliative measure serves, by abolishing the headache and vomiting, to so improve the patient's general condition that the medicinal treatment is far better tolerated. It, furthermore, has seemed to me to make the drug

administration much more efficacious, owing possibly to the lessening of intracranial venous stasis and consequent improvement of the circulation.

There are late complications, such as epilepsy and cranial nerve paralyses from atrophy, which may call for surgical intervention even when the disease has subsided through medicinal measures. Notable among the latter is a persistent facial paralysis which may demand a spinofacial or hypoglossofacial anastomosis.

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Meningeal Tumors. — Their symptomatology and diagnosis hinges entirely on the disturbances to which they lead in cerebral processes; hence it will be best to defer their consideration until the final section of this chapter, when they will be more fully considered with tumors of the brain itself. Certain points may be mentioned in passing. Owing to their approachability they represent the most favorable cases of tumor for surgical measures. They are apt to be of a much less malignant nature than true cerebral tumors, and their symptoms are due to compression of the brain rather than to invasion; for the pia acts as a barrier to invasion, and consequently enucleation is often possible without damaging brain structure. Owing to their superficial situation they are apt to give localizing symptoms, so that their exact situation can often be determined. They are usually slow-growing and may last for many years. Thus, the lateral recess (cerebellopontine) tumors may give no underlying symptoms of pressure until they finally compress the ventricular outlet. These leptomeningeal tumors, therefore, are not only the most favorable ones for direct approach and enucleation, but also when inaccessible, owing to their slow enlargement, they are equally favorable for simple decompressive

measures. Certain of the pachymeningeal tumors are, on the other hand, of a most malignant sarcomatous nature; they usually lead to absorption of the cranial bones and appear externally as soft and pulsating swellings.

PART IV.

THE BRAIN.

"The soul apparently resides in the seat of the judgment and the judgment apparently resides in the place where all the senses meet, which is called the common sense: and it is not all of it in the whole body as many have believed, but it is all in this part."—LEONARDO DA VINCI, *Windsor MSS.*

"It is true that very considerable injuries of the brain sometimes disturb the mental manifestations very slightly; and, on the contrary, that very slight injuries of the brain are often accompanied by the most violent symptoms."—SPURZHEIM'S *Phrenology.*

A thorough working knowledge of the structure and function, as well as of the pathologic anatomy of the organs which he ventures to treat, is an acquirement no less necessary for the surgeon than for the physician, if for no other reason than that it is in the power of the former, when unfamiliar with his subject, to do the most harm by his therapy, just as when he possesses this familiarity it is often in his power to do the most good. Our surgical text-books are an evidence that the time has not come when it is regarded as essential that the operator have any especial knowledge of the nervous system, but it will be for the ultimate benefit of neurology when specialists in this branch are as fully trained in matters of diagnosis, which hinge so largely on anatomy and physiology, as they are in matters of manual practice. A text-book of neurology is the best guide to neurologic surgery; particularly its chapters upon structure, function, and pathology, for those upon treatment are apt to be barren of surgical suggestion. It may be added, however, that surgery, under the safeguard of modern asepsis, when it is turned loose upon this most important structure in the human body is a dangerous form of handicraft.

ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS.

Development.—A clear idea of adult cerebral anatomy is only acquired through a knowledge of the development of the cerebrospinal system, and some facts may be briefly recalled.

Among them are the conversion, in the early embryo, of the primitive medullary groove into a canal; the dilatation of its cephalic end in a series of three sacs, representing the primitive fore-, mid-, and hind-brains; the subsequent subdivision of the fore- and hind-brain into two sacs, so that all told there result five primary vesicles whose cavities freely communicate. At an early date, from the most anterior of these primary vesicles there buds out a secondary cavity; this soon becomes mesially subdivided; its walls, for the most part, rapidly thicken; and finally, in the higher

mammals, it spreads backward until it completely overlies the other vesicles, thus forming the cerebral hemispheres.

The walls of the other vesicles likewise become gradually, though unequally, thickened. The roof of the second portion of the fore-brain (third ventricle) is, however, a notable exception to this rule; for this, remaining thin, becomes displaced downward and forward by the folding back of the hemispheres and carries with it a vascular membrane (velum interpositum), the edges of which consequently become continuous with the inner border or place of attachment of the hemispheres. Hence it is that the choroid plexus—the marginal vascular fringe of this velum—juts into the mesial edge of the cavities of the hemispheres (lateral ventricles). Throughout this entire metamorphosis the cavities of the original vesicles, though much altered in form, retain their free intercommunication.

During the formation of the hemispheres the vesicular walls have become rapidly, though irregularly, thickened. An especial and an early thickening (the corpus striatum) takes place at the outer side of the ventral surface, in consequence of which the outer wall at this point becomes less expanded than in other parts and a fossa (Sylvian) is left, in the depth of which the insula (island of Reil) lies, forming a cortical area which finally becomes totally buried by the folding over it of the rest of the hemisphere. Thus, the first indication of an irregularity in the otherwise smooth and bilaterally placed hemispheres appears at an early period as a deep cleft (Sylvian) separating temporal and parietal lobes.

Furthermore, from the thickening outer surface of each lateral vesicle there originate several bundles of fibers which pass toward and through the basal thickening (corpus striatum); the most important of these bundles (the pyramidal tract) passing through its center forms the internal capsule. At the fifth month, up to which time the hemisphere, except for the fossa Sylvii, has remained smooth, fissures (sulci) begin to appear. They are due to irregular elevations (gyri), the number and prominence of which increases until at the time of birth almost all of those which are present in the adult are found fully developed, although they have not as yet reached their complete adult configuration. The more important and deeper fissures subdivide each hemisphere into its lobes—occipital, temporosphenoidal, parietal, and frontal.

It is presumable that for some time after birth there is a progressive increase in the number of cellular units which go to make up the central nervous system, and consequently as the different areas gradually attain their full development, alterations necessarily occur in the surface topography of sulci and gyri, even though they roughly conform to their original type. It is due to this that the central fissure (Rolandic) which separates frontal from parietal lobe, loses, soon after birth, its simple, straight form and becomes sinuous in outline, presenting the well-known genua, due to the fact that there have been either accessions of growth or actual new elements added to the cortical stations of the pyramidal tract, forming centers for leg, arm, and head which lie anterior to this central fissure and are separated by the genua.

At the time of birth, as Flechsig has shown, medullation of the nerve tracts is not yet complete, and hence the brain of the newborn is much less firm and resistant to injury than later in life when its nervous elements have become completely ensheathed. The first tracts to become medullated are those subserving the special senses—the visual, gustatory, auditory, and olfactory tracts—and by observing their development it has been possible to determine the cortical seats of representation of the special sense organs. More tardily, medullation takes place in the pyramidal tract, the process occurring first in the cells nearest the great mesial groove between the hemispheres, namely, the centers for the lower extremity; subsequently medullation occurs in the areas for arm, face, etc.

Relation to Skull.—The fully developed brain completely fills the cranial chamber, the configuration of which is determined under ordinary circumstances more by intracranial influences of growth than by adventitious extracranial influences. The shape of the brain, it is true, may be modified by long-continued pressure against the skull, as practised in certain barbaric tribes, but it is doubtful whether the total quantity of brain can be modified by any such influence. Experimental attempts on animals to restrict cerebral growth by long-continued extracranial pressure have been unavailing. This matter has an important bearing upon a form of treatment (linear craniectomy) proposed for cases of cerebral maldevelopment, on the view that microcephalus is due to a primary closure of sutures which prevents cerebral expansion, rather than to a primary insufficiency of brain mass. It may be noted in this connection that local cerebral defects—whether from interrupted growth or from destructive lesions which have occurred at birth or during infancy—oftentimes indicate their presence by the flattening of the overlying portion of skull. Contrariwise, the cranium in the young, even long after the sutures have closed, yields quickly to abnormal growth or increase in size of the brain, as seen in cases of tumor or hydrocephalus.

Furthermore, it must be remembered that normal variations are great not only between the brains of individuals, but between those of different races. In individuals, for example, there may be a relatively great disproportion between the amount of brain matter anterior and that posterior to the central fissure, and Froriep refers to two types—the "frontopetal," in which the greater portion of the brain lies anterior to a perpendicular line erected at the auditory meatus, and the "occipitopetal," in which it is posterior to this line. And in these two forms not only the position of the Rolandic fissure, but its angle of obliquity as well, is greatly altered. There is probably a still greater variation between races. Bean has pointed out the great difference in the size and shape of the Caucasian and Ethiopian brains, particularly as regards the frontal lobe. It is in consequence of these things that no accurate extracranial measurements may serve to indicate, other than roughly, the situation and the form of the central or other cerebral fissures.

The Blood-supply.—The chief arterial stems, which have a free intercommunication through the circle of Willis, supply the hemispheres through three main branches: (1) The anterior cerebral supplies the first and second frontal convolutions and all of the mesial surface back to the parieto-occipital fissure; (2) the middle cerebral, emerging at the Sylvian fissure, supplies the insula, the third frontal, the pre- and post-Rolandic convolutions, the parietal lobe, the first and second temporal convolutions, and part of the occipital lobe—in other words, most of the exposed outer surface of the hemisphere, and (3) the posterior cerebral supplies the second and third temporal gyri, the mesial part of the occipital lobe, and the under surface of the temporosphenoidal lobe. The vessels to the deeper structures are given off directly from the circle

of Willis, or else from these main stems; those of chief moment penetrate and supply the basal ganglia. There are also three branches of considerable size which arise from the vertebral and supply the cerebellum.

The occlusion of any one of these large vessels gives characteristic and localizing signs, and operative ligation of the larger stems near the base of the hemisphere must be undertaken with caution, lest it lead to softening of an extensive cerebral area. It is for this reason that in operations for tumors it is desirable to ligate the individual twigs in the environ of the growth, rather than the main branch at a distance. This applies also to ligation of the carotid, for in spite of the usual free anastomosis at the circle of Willis, extensive softening may follow this operation.

The **venous** circulation within the brain itself and over the cortex is also important. Of chief interest is the peculiar arrangement of vessels which, collecting blood from the basal ganglia and from the choroid plexus, unite in the venæ Galeni, which in turn empty into the sinus rectus. Compression of these latter vessels, or their occlusion from any cause, leads to serious symptoms of stasis and to internal hydrocephalus.

The vessels of the hemisphere course over the surface and empty, for the most part, into the superior sagittal sinus by long, oblique passages directed forward, that is, against the current in the sinus. The two largest and most important of these superior cerebral veins lie in or near the central or the two adjoining sulci; they communicate freely with the large veins lying in the Sylvian fissure. Similar large vessels radiate from the temporo-sphenoidal lobe and enter the lateral sinuses. The points of attachment or anchorage of the hemispheres to the dura at the points where these large collecting veins cross the subdural space are of prime surgical importance; they occur chiefly at the parasinoidal sinuses a centimeter or two from the mid-sagittal line; also at the occipital pole, under the temporal lobe; and there is in addition a point of anchorage at the outer side of the cerebellar hemisphere.

It is undetermined whether the cerebral vessels possess **vasomotor nerves.** By intravital methods of staining it is possible to demonstrate nerves which are histologically akin to the vasomotor nerves of other parts of the body, but they have never been unequivocally shown to possess a dilator or constrictor function. Certainly from the results of experimental observations it may be said that, even though vasomotor nerves be actually present, their physiological action differs from those to the splanchnic field under the control of the vasomotor center in the medulla.

The **lymph circulation** in the brain, though doubtless abundant, is of a peculiar nature not well understood. It has been demonstrated that the cerebrospinal fluid—which probably has no direct connection with the lymphatic system—escapes from the subarachnoid space directly into the larger sinuses and thus reaches the blood stream without the intervention of glands. Asher has shown that in all parts

of the body lymph must become altered in its passage through glands before it enters the general circulation; for unaltered it is very toxic. It would be surprising should there prove to be an exception to this in the intracranial lymph circulation. It is possible that lymphatics from the surface of the brain may pass by channels through the cranial foramina into the external coverings and thus into the cervical glands without any actual communication with the subarachnoid space. (For Cerebrospinal Fluid see p. 105.)

Physiology of Cerebral Circulation.—Certain general tenets of surgical import, for which we are in large part indebted to Leonard Hill's studies, may be mentioned:

The brain pulsates synchronously with pulse and respiration. Its greatest expansion is in expiration, due to the accompanying slight venous stasis. The cardiac pulse is transmitted to the cerebral veins. These movements are made possible by the ebb and flow of cerebrospinal fluid. Any increased tension of the dura mater decreases the exhibition of the cerebral movements.

As there is no evidence of the existence of a local vasomotor mechanism it follows that cerebral anemia from spasm of the cerebral arterioles does not occur, though it must be confessed that clinical evidence furnished by cases of Raynaud's disease, in which local cerebral symptoms occur, speaks against this view of the experimentalists.

According to the "Monro-Kellie doctrine" the total quantity of blood within the cranium is, under all physiological conditions, practically invariable. The amount of blood which passes through the cerebral vessels in a given time does, however, vary in wide limits.

Under normal circumstances the intracranial pressure may vary considerably [between 0 and 50 mm. of Hg. (Hill)] from circulatory alterations alone, brought about by changes in position, straining, etc. Venous congestion, when kept up, may, however, become of great pathological significance.

Conditions of disease, on the other hand, leading to the presence of a new body in the brain—a clot, a tumor, hydrocephalus, etc.—materially affect the amount of blood in the brain. They lead primarily to venous congestion, and only to arterial anemia when the pressure due to the crowding of the new body exceeds the general arterial pressure. Even under these circumstances anemia is for a time overcome by a compensatory rise in arterial tension, due largely to constriction of the splanchnic field. The cerebral sinuses are, in a measure, compressible.

Under many circumstances gravity plays an important rôle in cerebral circulation, the vasomotor splanchnic mechanism being the regulatory agent and one which is more perfect in its action in upright animals than in those normally on "all fours." Inefficiency of the splanchnic constrictors due to injuries, to chloroform, etc., is of vital importance, as the lowered pressure lessens the cerebral circulation and leads to anemia. Hence the feet-down position when the splanchnic compensation fails may lead to a cessation of cerebral circulation, with fainting and even death. Some form of support, like Crile's rubber suit, alone will justify this position when the vasomotor system is affected.

In cerebral anemia, whether due to vasomotor paralysis and posture, to bloodletting, to occlusion of important vessels by operation or disease, symptoms occur which are comparable with those of asphyxia. There is first unconsciousness, followed by slow pulse and rise in blood pressure; later by a fall in blood pressure, a rapid pulse, and death (see Compression, p. 188 *et seq*).

The rapid occlusion of the main source of arterial blood (the two carotids) is

likely to lead to fatal symptoms of anemia; their gradual occlusion can safely be carried out by some such measure as Halsted has described.

The tension of the cerebrospinal fluid and cerebral venous pressure is normally the same. If the former is increased over the latter the fluid escapes into the sinuses (unless they are occluded). If the venous pressure becomes greater than the cerebrospinal fluid tension there is a damming back of cerebrospinal fluid.

Localization of Function.—It was the teaching of Flourens that all parts of the cortex possessed the same significance; his view being that lesions of the hemispheres would produce depression of function merely according to their extent, but regardless of their situation. Thus, the phrenologists, Gall and Spurzheim, with their somewhat visionary hypotheses, were, in principle, nearer the truth in their territorial subdivisions than their more distinguished contemporary.

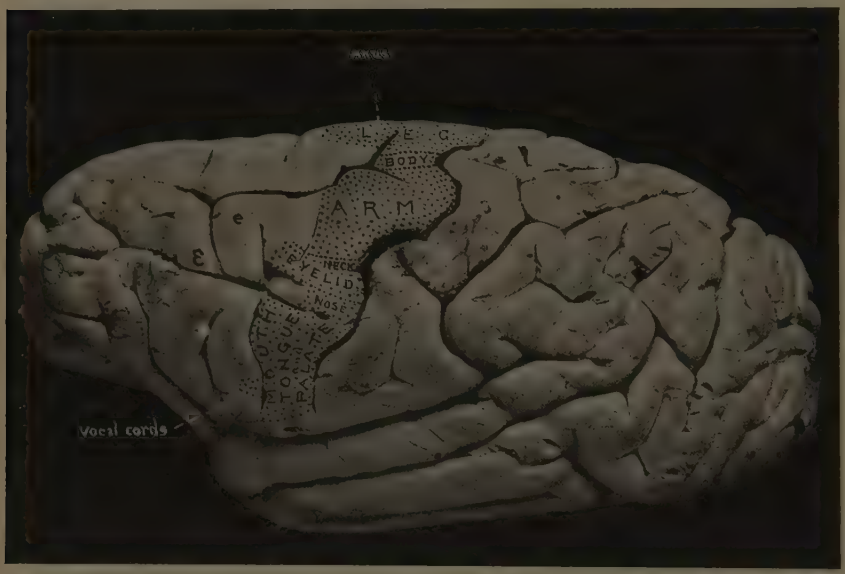


FIG. 83.—BRAIN OF GORILLA SHOWING EXCITOMOTOR AREA AS DELINEATED BY CORTICAL FARADIZATION.
Note the presence of three genua (*superior*, opposite body; *middle*, opposite neck areas). (Kindness of Prof. Sherrington.)

From clinical observations, Broca, in 1861, by demonstrating the seat of articular language; Hughlings Jackson, in 1864, as a result of the study of focal epilepsy; and Bastian, in 1869, through further observations on disturbance of speech, undermined, in a measure, the doctrines of Flourens; but they did not completely crumble to the ground until 1870, when, by experimental methods, Fritsch and Hitzig demonstrated that there were areas of the dog's cortex which gave excitomotor responses to galvanic stimulation. Ferrier, in 1873, using the faradic current, verified and amplified their observations, and the subsequent studies of Burdon Sanderson, Munk, Schiff, Schäfer, Horsley, Mott, Bianchi, and a host of others have served to fully establish the theory

of separate localization of cortical function. The results of these clinical and experimental researches have lately received further confirmation by embryological and histological studies, notable among which are Flechsig's observations on the periods of myelinization of the separate tracts, and the investigations by Mynert, Betz, Ramon y Cajal, and more recently by Campbell, which have thrown light on the structural differences of the various cortical areas.

The localization theory, however, was not received without opposition on the part of many clinicians and experimentalists, not a few of whom, like Goltz, were led to interpret their experimental observations as an argument against the localization of function. Even among those who supported the theory in general, disagreements have occurred in regard not only to the delineation, but also to the exact function of particular areas. The chief strife has been waged over the so-called sensorimotor cortex in the effort to determine whether there was a separate or a superimposed field of representation for sensory perception and motor discharge. Doubtless the chief reason for adherence to the view of superimposition of these areas was due to the fact that lesions of the supposed motor field, at a time when motor centers were thought to lie both anterior and posterior to the central fissure, often led to sensory disturbances. We now know, through the more accurate methods of cortical stimulation introduced by Sherrington and Grünbaum (1901), that that portion of the cortex which is directly excitable by a unipolar electrode consists of a narrow strip which lies anterior to the central fissure and extends to the depth of this fissure on its anterior surface alone. This circumscription of true "motor cortex," together with the subsequent histological demonstration that this zone corresponds exactly to the distribution of the Betz cells, has finally led to the general view that the central fissure divides the cortex into an anterior motor and a posterior sensory field, intricate though the commissural connections between these two fields may be. Sherrington and Grünbaum's observations on the higher anthropoids (Fig. 83) have been confirmed for man by Krause, Frazier, and the author.

The Excitomotor Cortex (Figs. 84–86).—This is limited to a narrow strip, 1 cm. or more in width, of the exposed part of the *gyrus centralis anterior*, but extends to the depth of the *fissura centralis* (*Rolandi*). Hence its chief portion is not on the visible surface, and consequently a lesion which actually involves the motor cortex may lie far below the exposed surface of the hemisphere. The anterior edge of the excitable area shades off without sharp demarcation; its upper limit overlaps slightly onto the mesial surface (*lobulus paracentralis*) and its lower limit falls short of the Sylvian fissure.

The Rolandic fissure is not a straight line, but is broken by two, or sometimes three, more or less well-developed angles (genua), formed, I believe, by the swellings above and below them, made by the aggregations of cells controlling movements in leg, arm, face and, still lower down, jaws, tongue, etc. Opposite to the upper two genua the motor strip is less wide and its representative movements less complex, occurring as they do in neck and trunk. Thus, the genua are valuable surgical landmarks, particularly the middle and inferior ones, for they are more often brought into view. Above the superior genu there is but a small triangle of motor cortex

FIG. 84.

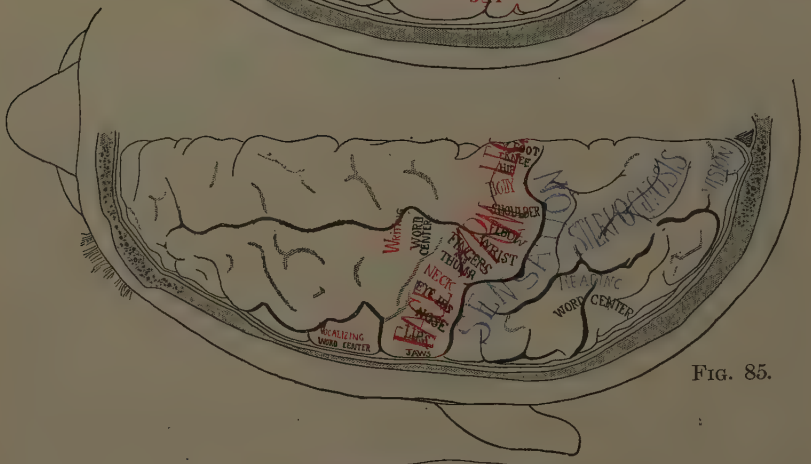
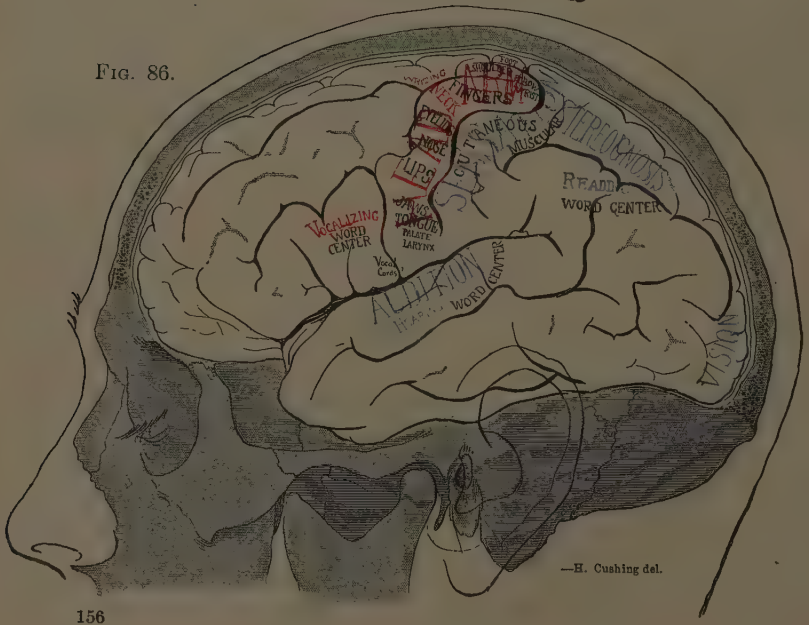


FIG. 85.

FIG. 86.



which can be exposed, and it gives, on stimulation, movements in hip, knee, and toes; opposite to this genu lie centers for movements of thorax and abdomen; between it and the middle genu lie centers for the upper extremity, the shoulder being represented higher than fingers and thumb; opposite to the middle genu are centers for the neck and below it those of the face—eyelids above and lips below; centers for jaws, tongue, vocal cord, pharynx, etc., are still lower, usually below an inferior genu.

Extirpation of these areas leads to loss of movement, which is more or less complete and permanent according to the totality of the extirpation and to the degree of bilateral representation of the particular movements concerned. Sensation is not affected.

Certain complex movements of a higher order may be obtained by stimulation of areas adjoining the true motor cortex. Thus, below the *gyrus centralis anterior*, in the *pars opercularis*, sucking, chewing, sneezing, and vocalizing movements may be obtained (note that this is near the vocal speech center of Broca); and from the *gyrus frontalis medius* movements of the head and eyes to the opposite side may be elicited.

The pathway from the motor cortex is the pyramidal tract, whose fibers degenerate throughout their full length after injury to their cortical cells.

The Sensory Field.—It has long been known that lesions near the *fissura centralis* often lead to sensory disturbances. The observations of Sherrington and Grünbaum, showing that the posterior confines of the motor cortex lie in the floor of the fissure, paved the way for further study of the *gyrus centralis posterior*, and Campbell's researches in particular would seem to show that the primary registration of "common sensation" occurs there. He has demonstrated that histological changes are found in the cortical cells of this gyrus after amputations, in tabes, etc. The area occupies much the same position posteriorly in regard to the *fissura centralis* that the motor area holds anteriorly. It is largely hidden from view on the posterior surface of the fissure and does not extend back over more than the anterior half of the exposed postcentral gyrus.[1]

I have had occasion to learn, from extirpations of the postcentral gyrus in cases of focal epilepsy with a sensory aura, that temporary sensory disturbances of the cortical type occur after such lesions. It is to be noted, furthermore, that some disturbance of motion follows such extirpations, but a palsy of this type is due to loss of afferent impulses and is unassociated, as I have found in 2 cases, with any degeneration of the pyramidal tract.

The fibers to the sensory field pass from the thalamus in the "cortical lemniscus" (Monakow) of the *corona radiata* to the post-Rolandic territory. In their course they lie in the posterior part of the *capsula interna*.

The forms of sensation, registration of which we may now, with some assurance, place in the near postcentral region, are the tactile sense, the muscular sense, and the power of discriminating points in contact. It is evident also that as one goes further back from the *fissura centralis* and approaches the posterior association field of Flechsig, sensation becomes more complex, so that more extensive and deeper lesions

[1] It may be recalled that Ferrier placed the sensory cortex in the *gyrus hippocampus;* Schäfer and Horsley in the *gyrus fornicatus.*

FIGS. 84, 85, 86.—DIAGRAMS ILLUSTRATING THE MORE DEFINITELY LOCALIZED OF THE CORTICAL CENTERS OF THE EXPOSED PART OF THE HEMISPHERE, IN RELATION TO THE MAIN FISSURES AND CONVOLUTIONS; ALSO THE "WORD CENTERS" (SENSORY AND MOTOR) INVOLVED IN THE SPECIAL MECHANISM FOR SPEECH. (RECEIVING SENSORY STATIONS IN BLUE; DISCHARGING MOTOR STATIONS IN RED.)

Drawn by accurate orthogonal projection of actual dissection. Note that centers for lower extremity are practically invisible from side and that the best view of the motor field is obtained from above.

are necessary to interrupt its transmission. The senses of pain and of temperature lie probably in the intermediate postcentral zone of Campbell (Fig. 87) and that for the recognition of objects—the stereognostic sense in particular—is located as far back as in the parietal lobe (Walton and Paul).[1]

The Visual Cortex.—Practically all investigators agree in placing the primary receiving station for visual impressions in the occipital lobe, particularly on its mesial surface in the calcarine region. The investing (visuopsychic) field is concerned with "the final elaboration and interpretation of these sensations." Myelinization of the fibers to the former occurs early; of those to the latter, not until the child is capable of interpreting visual stimuli.

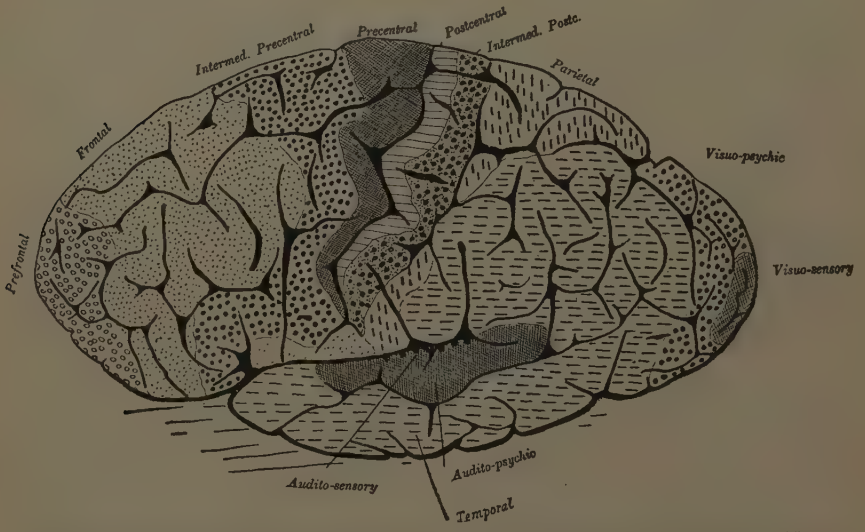


FIG. 87.—CORTICAL FIELDS DETERMINED BY HISTOLOGIC VARIATIONS IN NERVE FIBERS AND NERVE CELLS. (Campbell.)

The visuopsychic field extends on the outer surface (of the left side) in the second occipital convolution as far as the angular gyrus, where lies the visual word center (reading) (Fig. 86) which participates in the speech mechanism. The lingual lobule below the *fissura calcarina* appears to be associated with color perception.

The Auditory Cortex.—Auditory impulses appear to be received primarily at some portion of the *gyrus temporalis superior* and to be "converted into conscious perceptions" in adjoining parts of the temporal lobe; those on the left side in particular being concerned with the auditory end of the speech mechanism. Extensive lesions on the right side may give rise to no appreciable impairment of hearing on the same side, and there is much confusion over the unilaterality or otherwise of the registration of auditory impulses.

The elaboration of the primary stimuli into tone perception, word perception, etc., occurs in the outlying districts, namely in the auditopsychic area which envelops the primary receiving station.

The Olfactory Cortex.—The *lobus pyriformis* is generally regarded as the chief cortical center for olfaction, but there is a division of opinion as to the part played by the adjoining areas of the *gyrus uncinatus, cornu Ammonis*, etc.

[1] A case of almost total hemianesthesia with astereognosis, but with no true motor paralysis, due to a lesion in the parietal lobe, has been recorded in detail in the *New York Medical Journal* for Jan. 26, 1907.

The **gustatory area,** like the above, is not definitely determined, but it also lies probably at the lip of the limbic lobe, in the neighborhood of the uncus. This, topographically speaking, would place both of these areas, for taste and smell, in a situation just to the outer side of the pituitary fossa—a matter of considerable importance, as lesions confined to this area of the limbic lobe not only give characteristic symptoms, but are surgically approachable.

The Four Cortical Areas Concerned in Speech—in Right-handed People (Fig. 86).—(1) The center for the recognition of spoken words lies in the outskirts of the primary center for hearing in the *gyrus temporalis superior* of the left temporal lobe. This doubtless is the first center concerned in the development of the faculty of language, in normal individuals, at least; for we must remember that speech may be acquired primarily through the sense of touch as exemplified in Helen Keller's remarkable case.

(2) Since Broca, and until the recent doubts cast upon it by Marie, the posterior end of the *gyrus frontalis inferior* has, by common consent, been regarded as harboring the centers for motor or vocal speech. These auditory and vocal word centers—Wylie's "primary couple"—may be developed in the uneducated with but little further advance. With later education is acquired the interpretation (reading) and the making (writing) of the symbols of language.

(3) The visual word center concerned in reading has been definitely placed in the *gyrus angularis* in the outskirts of the visuopsychic field, and—

(4) The so-called writing center, if such exists, has been placed at the posterior end of the *gyrus frontalis medius*—in other words, near the primary centers for movements of the hand and fingers. It is not improbable also that there is a fifth center in the parietal lobe, associating the sense of touch with the speech mechanism. It is to be remembered that no part of the speech mechanism, so far as its cortical centers are concerned, can be upset without affecting in some degree all other parts, though the most serious disturbances result from lesions of one of the "primary couple."

The Association Fields.—Other parts of the cortex than those which have been described are concerned, so far as is known, only with the complex processes of association, and lesions of these areas are largely "silent," so far as our present possibilities of neurological examination go. An exception may be made in the case of the frontal lobes, particularly the "prefrontal" portion of the left hemisphere, where the higher psychic or intellectual faculty has been placed by many observers.

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THE SYMPTOMATOLOGY OF ORGANIC LESIONS.

Although the cerebrum is subject to a great variety of morbid conditions, the symptoms which are manifested thereby are relatively few. In diseases of the nervous system they depend in general more upon the situation of the process than upon its nature. Thus, an obstructive lesion of the motor path, at any point between the cortex and the peripheral end-organs, results in paralysis, whether it be due

to a neoplasm, a vascular lesion (hemorrhage, thrombosis, or embolism), inflammation, injury, compression, or what not.

In a broad sense the symptoms may be divided into (1) *subjective* symptoms, appreciated only by the patient, and *objective* ones, which are obvious to the observer; (2) *general* symptoms, or those which characterize many intracranial processes regardless of their seat, and *focal* ones, which indicate the situation of the lesion. Subjective or objective symptoms may be general or focal, and vice versa; general or focal symptoms may be either largely subjective or objective. For example, a tumor involving the cortical center of the left hemisphere, which presides over movements of the arm, may give subjective symptoms which are general and due to pressure, such as diffuse headache, nausea, or dizziness; or it may give others which are focal, as weakness or diminished sensibility in the arm. It may give objective symptoms which are general, as shown by vomiting, choked disk, and slowed pulse, or ones which are focal, such as muscular atrophy, brachial spasticity, or a monoplegic spasm.

The symptoms, broadly speaking, may further be divided into those which are *irritative* and those which are *paralytic*. These again may be general or focal, subjective or objective.

General Symptoms.—These are headache, vomiting, choked disk, and other evidences of venous stasis, vertigo, convulsions, etc.

Headache.—This is of common occurrence (1) in association with a variety of conditions not primarily cerebral; but a patient subject to persisting headaches should rest under the suspicion of having primary intracranial disease until this can be definitely disproved. Cephalalgia of extracranial origin accompanies chronic processes in the mastoid or accessory sinuses, eye-strain, etc. (the so-called reflex headaches), anemia, disturbances of digestive or menstrual function, fevers, etc.

Headache (2) is almost invariable in diseases of the meninges, particularly when the sentient dura is involved, and it is my impression that most headaches—those of the migrainous, as well as of other types—are largely dural in origin. This membrane is innervated entirely by the trigeminus, with the exception of a small area about the foramen magnum supplied by vagal fibers. As the recurring pain of "hemicrania" is a not infrequent antecedent of facial neuralgia, this may possibly be considered as a form of dural (trigeminal) neuralgia. The headaches of meningeal inflammation, particularly of the luetic type, may be profound.

Of chief importance, however, are the headaches (3) due to intracranial pressure from any cause whatsoever. In tumor, edema (whether of traumatic origin or associated with nephritis), internal hydrocephalus, serous meningitis, etc., the pain is doubtless brought about by abnormal tension of the dura or of its membranous expansions into falx and tentorium. As a rule, headaches due to pressure are of no particular help in localization, for regardless of the seat of the lesion, they may be referred to the vertex, to the frontal region, or to the occiput. Occasionally, however, taken in conjunction with other symptoms, their situation may be helpful—as in certain subtentorial lesions in which the chief discomfort may be referred to the corresponding suboccipital area. This is especially true of local headaches which are associated with an area of tenderness.

There are all gradations of headache, from a dull sense of pressure or fulness, to agonizing and prostrating pain.

Vomiting, with or without *nausea*, and irrespective of any gastric disturbance,

is a common symptom of any acute or chronic cerebral lesion, especially of those which encroach upon the intracranial space. It may be an early symptom of concussion or contusion; and more or less nausea, doubtless due to the secondary edema, may persist after these acute traumatic lesions for days. In chronic processes it is an even more characteristic symptom. Sudden projectile vomiting, often accompanied by nausea, is well known as a general symptom of pressure resulting from brain tumor, from the edema of nephritis, etc. The physiology of the process is not determined. Some believe that there is an especial center in the medulla, irritation of which leads to vomiting.

Vertigo is a frequent subjective phenomenon, but being a common symptom from causes other than cerebral ones it is of importance only in association with other evidences of organic disease of the brain. It is most pronounced in lesions which involve the auditory nerve, the mid-brain, or cerebellum.

Choked disk ("optic neuritis"), if of a degree sufficient to cause dimness of vision, may be a subjective as well as an objective phenomenon. It is one of the most important indications of intracranial pressure, and an ophthalmoscopic examination should be made upon every case in which, from headache alone, there may be a suspicion of intracranial disease. It is not sufficient for the examiner to be able to recognize a choked disk when it is full-blown, but the slight edema of retina and nerve head with early distension and tortuosity of the veins which precedes actual "choking," must be appreciated, for they are of the utmost help in making an early diagnosis. The symptom, on the whole, is merely an evidence of general pressure, although occasionally a unilateral choking or a process more advanced in one side than the other may have a certain localizing value and suggest the presence of disease upon the corresponding side of the head. As a matter of fact, however, the most pronounced cases of choked disk occur in association with subtentorial processes, the stasis in the eye-grounds being brought about by an obstructive hydrocephalus; and, inasmuch as this leads to a general and equal increase of pressure the process on the two sides will be equal in degree, unless there chances to be some structural difference in the sheaths of the two optic nerves.

Many theories have been advanced in explanation of this phenomenon. The more important views are those of von Graefe (1860), who thought that it was due to compression of the cavernous sinus leading to venous stasis in the eye. The Schmidt-Manz "*Transporttheorie*" (following the discovery of Schwalbe that the intravaginal space of the optic nerve communicates with the intermeningeal spaces of the brain) attributes a choked disk, in cases of increased pressure, to the stasis of cerebrospinal fluid into this space, leading to an ampulla-like distension of the optic sheath. Parinaud (1879) thought that a choked disk could only occur in association with internal hydrocephalus or other conditions associated with an edema, which was supposed to spread along the optic nerve from the brain itself. Von Leber (1881) expressed the view that it was an actual inflammation—a "papillitis"—brought about, irrespective of edema or stasis, by the growth; just as a "neuroretinitis" is said to be caused by circulating toxic products in chronic renal disease. Other theories—that it is of reflex origin; that it is due to sympathetic disturbances, etc.,—have been advanced, but they are less widely supported.

Generally speaking, we see that there are mechanical views opposed to toxic views, each of which has been upheld by a number of eminent clinicians and investigators; but the general employment of the term optic "neuritis" would seem to indicate that it is widely regarded as an inflammatory process. Recent clinical and experimental observations showing the rapid subsidence of a choked disk after decompressive operations, serve to modify the views which many have held, and with Sanger, Axenfeld, and others I believe that almost all, if not all, cases of choked disk are primarily of mechanical origin and do not justify the term "neuritis." It

is a quibble to say that the transudation of fluid anywhere is necessarily associated with some toxic agency, but the stasis edema which occurs in consequence of the application of a tourniquet on an extremity, though toxic in a sense, is more properly considered mechanical, since the removal of the mechanical agent and relief of the stasis allows the edema rapidly to subside.

When the swelling of a choked disk has become pronounced and has been of sufficiently long duration hemorrhages occur in the nerve head and retina as a result of the stasis; this is followed by an infiltration of round cells and, unless the process is checked, organization progresses until the fibers become physiologically "blocked" and light is no longer transmitted. The loss of vision occurs primarily as a peripheral shrinkage of the field for form and color and it must always be remembered that normal acuity of central vision may remain oftentimes until late in the process.

Other less important general symptoms may be mentioned, among them **convulsions,** which in this case are invariably associated with loss of consciousness. They may occur even when there is a local lesion and yet not be indicative of its situation, for only when the lesion involves primarily some center, irritation of which leads to symptoms which can be appreciated by the patient during conscious moments or can be observed by the onlooker before the convulsion becomes general, can their seat of origin be determined. Focal lesions, therefore, apart from the so-called motor fields, may lead to a general, rather than a focal convulsion. General convulsions of cerebral origin involving the entire musculature may arise from toxic causes, apart from any organic lesion; such are especially common in children.

Grades of stupor are usual in almost all intracranial processes, especially when acute or subacute. They may vary from simple drowsiness, with yawning, etc. to profound sleep from which the patient cannot be aroused; to lethargy in which he is totally indifferent to his condition, even though seemingly awake; to stupor, in which he is oblivious of his surroundings, though in its lighter grades he may be aroused so as to respond to questions, of which he has no subsequent memory; to coma, with profound unconsciousness and usually with serious respiratory symptoms. Corresponding degrees of unconsciousness may be of toxic origin and occur in acute alcohol poisoning, in diabetes, etc., or they may be due to circulatory disturbances, whether from acute anemia or from the venous stasis brought about by intracranial pressure. They not only accompany all cranial injuries of any severity, due to the pressure of hemorrhage, edema, etc., but they also occur in meningitis and internal hydrocephalus as well. When unconsciousness is profound and results in coma, it is clinically of great importance to distinguish between its possible sources of origin—apoplexy (whether spontaneous or traumatic), sunstroke, alcoholism, uremia, narcotic poisoning, diabetes, epilepsy, etc.

Insomnia, emaciation, variations from the normal of *pulse,* of *respiration,* of *body temperature,* of *urinary secretion,* may be regarded as general symptoms in certain cases.

Focal Symptoms.—We have heretofore considered merely the general symptoms which indicate the presence of intracranial disease. When focal symptoms are present they may enable us to determine its situation. Roughly speaking, they are confined to disturbances of motion, of common sensation, and of the faculties of special sense.

On the Motor Side.—Motor paralysis is the most evident of all objective signs. Primarily it indicates the side of the brain involved. Less clearly it shows the situation of the involvement, whether cortical, subcortical, capsular, peduncular, pontine, or medullary. It may be hemiplegic and involve an entire half of the body, or only the trunk and extremities. It may be monoplegic and involve only one

extremity; paraplegic when the legs chiefly are affected; or diplegic when arms and legs both are impaired. Diplegia is a more usual evidence of spinal than of cerebral disease, though it occurs in cases of widespread intracranial hemorrhage or injury, particularly in the so-called "birth palsies." There are also various forms of multiple paralysis, in which individual muscles or groups of muscles supplied by single cerebral nerves may be involved.

Paralyses of cortical origin are apt to be accompanied or preceded by irritative symptoms, and are more commonly monoplegic in character. Paralyses of capsular or peduncular origin, since the fibers of the pyramidal tract are gathered there into a small space, are more apt to be hemiplegic. The so-called "crossed paralysis" is one in which a cerebral nerve palsy on one side accompanies paralysis of the limbs on the opposite side. Motor paralyses of pontine or medullary origin rarely fail to have accompanying symptoms, due to involvement of neighboring structures.

Spasticity of the muscles, with increased reflexes, occurs as the result of a lesion of the intracranial portion of the motor pathway. Should the lesion take place in the young there may be marked disturbance of growth. Contractures occur, whereby the limbs become fixed in awkward positions.

Motor irritation is evidenced most frequently by epileptiform seizures or convulsions. Local convulsions in the form of monospasm is a common indication of a lesion at or near the so-called motor area. The process leading to convulsions may be a quiescent one—a cortical defect; the cicatrix of an old healed focus of hemorrhage, etc.—or one which is progressive, as an enlarging cyst or tumor. A localized convulsion may be followed by paralysis; a general one, by a condition of profound muscular exhaustion; and when frequently repeated and the so-called status epilepticus ensues, death may result from asphyxia due to failure of respiratory movements. Other irregularities of movement—ataxic, choreic, athetoid, etc.—are usually the result of lesions in organs like the cerebellum or basal ganglia which modify movements, rather than of those affecting the primary conducting path.

On the Sensory Side.—Like those of motion, sensory disturbances may result from cortical or subcortical lesions. They also may be irritative and associated with subjective symptoms of paresthesia, or paralytic and accompanied by anesthesia.

Anesthesia may be complete or partial (hypesthesia) to various forms of stimulation—to pain, touch, pressure, temperature, etc. The deeper, as well as the cutaneous sense, may be affected and there may be loss of the sense of posture in an extremity, or of its position in space. Owing to the fact that a profound sensory paralysis leads to the shutting off of all afferent impulses, a certain degree of motor impairment is an almost invariable accompaniment. On the other hand, no sensory disturbance need accompany motor paralysis.

Irritative sensory symptoms may precede those of motion. Thus, the aura or warning of an impending convulsion may be an important clinical sign and may at times serve to indicate the situation of the lesion, even though the convulsion itself was general from the onset. The warning may occur as a subjective sensory, gustatory, visual, or olfactory impression.

Disturbances of *special sense perception* may be secondary not only to peripheral lesions of the nerves themselves, but also to lesions of the cerebral centers where special sense impressions are registered. A lesion may pervert or destroy any of the special sense qualities—smell, taste, hearing, and sight.

Regional Diagnosis.—From these brief generalizations we may pass to the symptomatology of lesions involving the various areas of cerebrum and brain stem. Only those signs which are unequivocal and which follow lesions of areas surgically approachable need be

considered. It must constantly be borne in mind that these symptoms are indicative merely of the situation of the lesion, not of its nature; also that extensive cerebral lesions may remain completely dormant, their existence—entirely unsuspected—being often disclosed at a post-mortem examination. These "silent" lesions affect systems of neurons whose function is so complex that their impairment lies beyond our present powers of recognition.

The Rolandic Area and Sensorimotor Pathways.—Their accessibility and their definite sensorimotor function explains the fact that most of the cerebral lesions successfully treated by surgical measures have been located in the paracentral convolutions. They comprise the anterior and the posterior central gyri, separated by the fissure of Rolando. The receiving sensory stations lie behind the fissure; the discharging motor stations lie anterior to it. From the anterior gyrus the motor neurons comprising the pyramidal tract pass to the spinal cord after decussation in the medulla. The afferent impulses, on the other hand, reach the posterior gyrus through various relays of neurons, the final one comprising a group of radiating fibers which arise from cells in the thalamus. The sensory pathway decussates largely within the cord; hence both motor and sensory disturbances of cortical origin occur in the half of the body contralateral to the side involved in the lesion.

An irritating lesion confined to a certain group of cells may cause, from time to time, a "discharge" of convulsive movements limited to the musculature controlled by those cells—focal or Jacksonian fits. It is characteristic of these seizures that the movements spread or "march" into groups of muscles presided over by cortical cells adjoining those primarily irritated, and thus in some cases the entire body musculature may in progressive sequence become involved in the fit. In seizures of this character consciousness may be retained up to a certain point, but it is usually lost before one entire side becomes convulsed; always so before the opposite side is involved. This same phenomenon of an advancing convulsion may be observed experimentally by prolonged electrical stimulation of any excitable point on the anterior gyrus.

Lesions which begin by inciting movements may end by abolishing them, in which case we may diagnose some progressive organic process like a tumor. A paralytic lesion of the anterior gyrus, whether it be due to trauma or disease, or the result of operative extirpation, leads to loss of motion without accompanying loss of sensory perception.

Lesions in the posterior gyrus—like those in the anterior—may be simply irritative and lead to numbness, to tingling or to other forms of paresthesia; or they may be paralytic and lead to hypesthesia or anesthesia. The distribution of these sensory disturbances assumes the so-called cortical form of anesthesia, namely, a sensory loss which is most marked at the extremity and shades off as the trunk is approached. Cortical lesions need be quite extensive before there is a considerable loss of sensation, and anesthesia is often a fleeting symptom in case the lesion becomes quiescent or is removed. Subcortical lesions which involve the sensory path occasion the most pronounced anesthesia and a certain disability of movement always results.

Degeneration of the pyramidal tract follows a destructive lesion of the anterior gyrus; the deep reflexes are increased and Babinsky's toe phenomenon is present (dorsal flexion on plantar stimulation). The superficial reflexes are diminished or lost after posterior lesions which affect sensation, but there may be no change in the deep reflexes.

The Frontal Lobe.—Clinically this is restricted to that portion of the hemisphere which lies anterior to the precentral sulcus (the "anatomical" frontal lobe,

on the contrary, extends to the Rolandic fissure). It may be divided into a prefrontal or non-excitable area, and a postfrontal area, within which are located centers for conjugate movements of the head and eyes, as well as for the motor part of the speech mechanism (vocalizing and writing).

Lesions confined to one frontal lobe, particularly of the right side, may be entirely latent. If extensive, however, they occasion characteristic impairment of mental faculties—loss of memory, apathy, diminished power of application, change of character with irritability, restlessness, and other evidences of weakening of the acquired powers of inhibition.

It is a question of dispute as to which of the frontal lobes presides most definitely over intellectual faculties, the general consensus of opinion being that in right-handed people the left prefrontal lobe is the more important of the two.

The third frontal convolution (Broca's), although its former significance has been rendered doubtful through Marie's recent observations, is supposed to preside over the function of vocal speech. Motor aphasia follows a lesion of this area, particularly when it is subcortical. A lesion, however, of any other portion of the speech mechanism may lead to disturbance of vocal speech, even though this area remains apparently unaffected. A few cases of pure agraphia have been recorded, in which lesions have been confined to the posterior end of the second frontal convolution.

The frontal lobes are not infrequently the seat of tumors, and few symptoms other than those due to general pressure may appear, although those mentioned above may be expected. In a progressive growth the anterior central convolution may become involved, and the diagnosis is aided by the onset of motor symptoms. The frontal lobes are often damaged in fractures of the skull, and lacerations thus produced not infrequently lead to subsequent mental deteriorations. In dementia paralytica the meningocortical changes are most advanced over the frontal lobes.

The Parietal Lobe.—As regarded clinically, this lobe does not include the posterior central gyrus, but lies between this and the occipital lobe. It is divided anatomically into a superior and an inferior lobule. The latter lies below the interparietal fissure and includes the supramarginal and angular gyri.

One characteristic symptom follows a destructive lesion of the angular gyrus of the left side in right-handed people; namely, word-blindness or the inability to appreciate the meaning of written language. A deep-seated lesion which involves the paths radiating from this word-seeing center is apt to involve the optic radiation as well, and consequently to lead to a half-blindness of the corresponding sides of both retinæ.

A lesion of the superior parietal lobule, particularly if it be subcortical, leads to disturbances of stereognosis; in other words, of the power to recognize through contact alone the form, or character of objects, or to name unseen objects when they are handled.

In the case of a subcortical lesion, especially if it encroaches on the postcentral gyrus, other sensory disturbances are apt to be present, such as loss of muscle sense, of position in space, or even of forms of common sensation.

The right parietal lobe is a comparatively silent area, given up largely to association paths.

The Occipital Lobe and Visual Pathway.—The former includes the posterior end of the hemisphere, both upon its external and mesial aspects. The parieto-occipital fissure forms its mesial anterior boundary, while it is limited on the convexity by an imaginary line passing from this fissure forward and downward to the annectant convolutions. This lobe includes on its mesial surface the cuneus and lingual gyrus, from which area the optic radiation passes, by the posterior end of the internal capsule, to the thalamus and external geniculate body, and thence by the

optic tract to the retinæ. A destructive lesion of this portion of the occipital cortex gives rise to blindness of the homolateral halves of both retinæ (homonymous hemianopsia), the patient being unable, when looking directly forward, to see objects upon the opposite side of the body until they are brought across the median plane. Hemianopsia may not be complete both for form and color, as one or the other may escape, and there are certain cases which indicate that a quadrantal hemianopsia may result from lesions in this situation. Should the lesion be a deep one and involve the optic radiation, homonymous hemianopsia may be accompanied by hemianesthesia or hemiplegia from implication of the adjoining paths for sensation and motion in the internal capsule.

When hemianopsia occurs suddenly, with symptoms of vascular obstruction, it usually indicates occlusion of the posterior cerebral artery in the neighborhood of the calcarine fissure. In these cases of hemianopsia from cortical lesions the pupils react in the usual manner when a ray of light is thrown on the blind halves of the retinæ (Wernicke's hemiopic pupillary reaction). A lesion of the optic tract must be anterior to the oculomotor nuclei to abolish this reflex. This, together with other features of hemianopsia, can be made out from the diagram (Fig. 88).

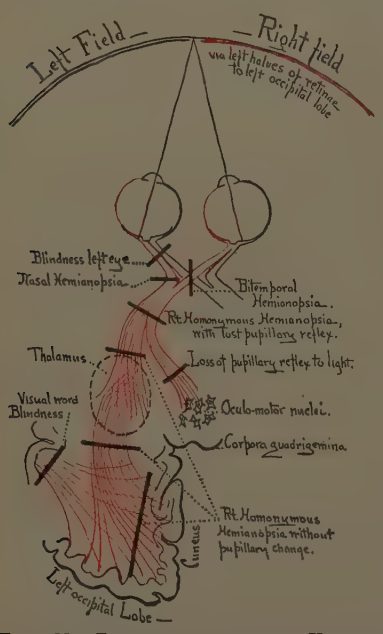

FIG. 88.—DIAGRAM TO SHOW VARIOUS FORMS OF VISUAL DISTURBANCE FOLLOWING LESIONS IN DIFFERENT PORTIONS OF THE LEFT VISUAL PATHWAY.

Irritative lesions of the occipital lobe may give rise to subjective flashes of light or of colors and these phenomena may constitute an aura for general epileptic convulsions originating from an organic process here. Experimentalists have been led to believe that centers for certain movements of the eyes are situated in the occipital lobe. If actually present they are of no diagnostic significance.

The Temporal Lobe.—This lies below the fissure of Sylvius and also forms the chief portion of the under surface of the hemisphere. Extensive lesions, such as an abscess which has destroyed a large part of the lobe, may remain entirely latent. A single pathognomonic symptom follows a destructive lesion of the superior temporal gyrus on the left side; namely, word-deafness or inability to apprehend spoken language. Such a lesion not only leads to word-deafness, but also seriously affects the entire speech mechanism, so that more or less word-blindness and vocal aphasia may accompany it.

The lower and anterior extremity of the temporal lobe forming the *uncinate gyrus* seems to be especially associated with the gustatory and olfactory senses. Destructive lesions in this situation may abolish the perception of taste or smell or both; and inasmuch as the tips of the temporal lobes are especially vulnerable in basal fractures, it is not uncommon for injuries of this nature to destroy or pervert these senses. Irritative lesions often lead to epilepsy which is inaugurated by an olfactory or gustatory aura. This is a common symptom in uncinate tumors.

A large portion of the temporosphenoidal lobe, at the present state of our knowledge, must be regarded as silent, for it can be thrown out of function without appre-

ciable symptoms. Hence it furnishes an ideal situation for decompression in cases of brain tumor (cf. Fig. 130 and page 235).

The Basal Ganglia, Crura Cerebri, Corpora Quadrigemina, and Pons.—Lesions in these situations, being for the most part inaccessible to the surgeon, are important chiefly from the standpoint of differential diagnoses. It may be said in general that growths involving these structures lead early to internal hydrocephalus, and are consequently most unfavorable even for decompressive measures; and that vascular lesions, aside from the large capsular clots of apoplexy (p. 215), are beyond remedy by any measures.

Briefly, lesions of the *caudate* and *lenticular nuclei* and *internal capsule* lead to contralateral hemiplegia, with or without sensory disturbance, according as to whether the posterior part of the capsule has escaped; lesions of the *thalamus* often lead to contralateral disturbances (1) of motion, such as athetosis, choreiform movements, etc., (2) of sensation, as paresthesia or hypesthesia, and also (3) to hemianopsia in many cases; lesions of the *crura*, to paralysis of the opposite limbs and of the motor oculi on the same side; lesions of the *corpora quadrigemina* to ophthalmoplegia, to blindness and deafness when the geniculate bodies are implicated, and to a reeling gait with vertigo and a tendency to fall backward; lesions of the *pons*, to varied symptoms, the most characteristic of which is a combination of cerebral nerve paralysis on the side of the lesion with contralateral paralysis of the limbs.

The Cerebellum.—Lesions here are common (tumors, cysts, abscesses, tubercles, hemorrhage, etc.), and many of them demand surgical treatment. The most characteristic symptom is instability of station and locomotion, with a coarse ataxia which accompanies volitional movement. These symptoms are bilateral if the lesion involve the middle lobe, or are largely confined to the homolateral side if a lateral lobe is involved. The symptoms, after acute lesions, may pass away entirely if a lateral lobe only has been affected; indeed, one lateral lobe may be totally excised and yet restoration of function be almost complete ; furthermore, it is not exceptionally rare to find at autopsy an unsuspected congenital absence of one lobe.

Rotary movements may be present with a tendency during progression to turn or fall toward the affected side, due doubtless to the ataxia and weakness of muscular control on that side. Peculiar convulsive seizures have been described, with forced movements (cerebellar fits). There is apt to be some tonic rigidity of the muscles of the neck with extension of the legs when the median lobe is affected, due possibly to the frequently associated internal hydrocephalus. Nystagmus is common and ocular deviation or paralyses occur, particularly with cerebral tumors.

In many cerebellar lesions there may be suboccipital tenderness, often more marked on the side of the lesion, and headache may also be referred to this region.

Craniocerebral Topography.—The discovery that different functions were localized in particular areas of the brain, and the knowledge—gradually acquired—of what symptoms were produced by lesions limited to these areas, paved the way for surgical measures directed toward their relief. It thus became imperative, particularly in the days when an attempt was made to approach these lesions through a small trephine opening, that the relationship of the cerebral convolutions and fissures to the surface markings of the skull should be established with the greatest possible accuracy. The science of craniocerebral topography arose; and a great number of investigations have since been devoted to the establishment of certain rules of measurement,

which give us, with sufficient accuracy, the average position of the main fissures of the exposed part of the hemispheres in their relation to definitely palpable points on the external cranial wall.

It may be recalled that Paul Broca was not only a pioneer in these studies, but was actually the first, in 1871, to put them to practical test in an operation performed for him on a patient with aphasia due to an abscess in the third left frontal convolution. Since then important contributions to the subject have been made, and particular rules have been formulated by Reid, Cunningham, Thane, Horsley, Chipault, Taylor and Haughton, Poirier, Dana, Krönlein, Chiene, Anderson and Makin, Le Fort and Debierre, Masse and Woolingham, Lannelongue

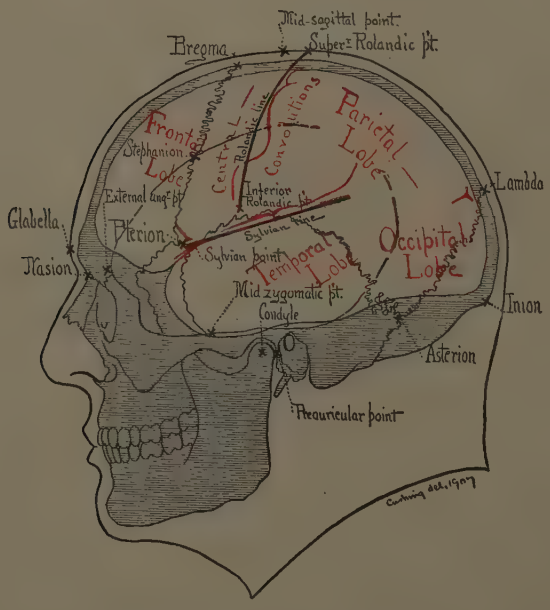

FIG. 89.—DIAGRAM SHOWING THE VARIOUS LANDMARKS UTILIZED AS POINTS OF MEASUREMENT IN CRANIOCEREBRAL TOPOGRAPHY.
Also, in red, main cerebral fissures and lobes of the exposed hemisphere.

and Mauclaire (for infants), Müller, Froriep, Kocher, and many others. Each of these prescribed rules has its good points, and the results of most of them, when applied to the same skull, do not vary much more than a centimeter or two. For the most part they are devoted to a determination upon the scalp of the upper and lower ends of the central fissure (superior and inferior Rolandic points), to the point of origin of the Sylvian fissure (Sylvian point), as well as to its line of general direction, and, less important, to the occipitoparietal fissure. The studies have been based largely on the average measurements of adult crania, and the difficulty of establishing the exact relationship of the encephalic and the extracranial landmarks has been overcome by a variety of ingenious devices.

The main principles of the superficial delineation of the fissures rest (1) upon the establishment of an equatorial base-line, from which perpendicular meridians or lines of intersection of coronal planes are erected at given points, and (2) upon angulation at given points, either from this base-line or from parallel circles, or from the mid-sagittal meridian. Reid's base-line is the favorite among English writers: it passes through the lower border of the orbit and middle of the external meatus and is nearly parallel to the upper border of the zygoma; the German base-line differs slightly from this in passing through the upper edge of the meatus. Perpendiculars according to various rules of measurement are erected (1) at the pre-auricular point between tragus and maxillary condyle; (2) from this condyle itself; (3) from the middle of the zygoma, and (4) from the posterior edge of the mastoid process. Zones parallel to the base-line ("upper horizontals") are made to pass through the upper border of the orbit, or from the external angular process, etc. Use is made also of particular points of union of the sutures, many of which are more or less definitely palpable and for which time-honored names are preserved—nasion, inion, pterion, bregma, asterion, etc. (Fig. 89).

A few of the better rules for the extracranial determination of the chief cerebral fissures may be given, and in the four diagrams (Figs. 90 to 93) are depicted *in toto* the general methods of Chipault, Krönlein, Taylor and Haughton, and Kocher.

The superior Rolandic point is found on the midsagittal line 55.6 per cent. of the distance from glabella to inion or external occipital protuberance (Reid); or one-half this distance plus ½ to ¾ inches (Thane); or one-half the nasio-inionic line plus 2 cm. (Poirier), or 2½ cm. (Kocher); or at the intersection of the midsagittal line with a coronal plane erected at the posterior border of the mastoid (Reid; Krönlein); or 5 cm. posterior to the intersection with a coronal plane erected at the pre-auricular point (Broca); or 2 to 3 cm. behind the coronal suture or bregma (Thane).

The *inferior Rolandic point* lies on the fissure of Sylvius 25 mm. behind its bifurcation or Sylvian point (Thane); or 3¾ inches below the superior Rolandic point on a line which makes an angle of from 67 to 71.5 degrees with the midlongitudinal line (Cunningham); or 7 cm. above the pre-auricular point on a line perpendicular to the zygoma (Poirier); or 5.5 cm. (varying from 4 to 7) above the zygoma on or slightly in front of this pre-auricular line (Thane).

The *Rolandic line* corresponds with a meridian dropped from the superior Rolandic point and making an angle with the midsagittal line of 67 degrees (Hare); or varying from 64 to 75 degrees (Thane). If extended below the inferior Rolandic point it should cross the middle of the zygomatic arch (Le Fort).

The *Sylvian point* may be located at the intersection of two lines; (1) from the auditory meatus to a point at 25 per cent. of the nasio-inionic line, and (2) from the external angular process to a point at 75 per cent. of nasio-inionic line (Taylor and Haughton); or at the intersection of lines (1) erected perpendicular to the base-line at the middle of the zygoma and (2) parallel to the base-line (upper horizontal) through the upper margin of the orbit (Krönlein); or 12 mm. above a horizontal line drawn back from the frontomalar suture to a distance of 35 mm. (Thane).

The *fissure of Sylvius* corresponds with a line joining the external angular process of the frontal bone and the point of intersection of the previously determined Rolandic line and the pre-auricular perpendicular line (Reid); or with a line drawn from

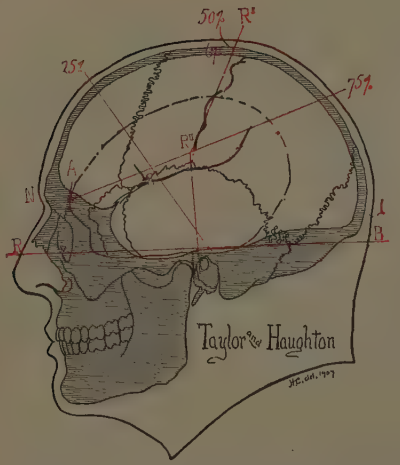

FIG. 90.—Sylvian line connects external angular process, *A*, with point 75 per cent. of distance *N* to *I*. Superior Rolandic point, *R'*, lies ¾ inch behind mid naso-inionic point (50 per cent.). Inferior Rolandic point, *R''*, lies at junction of Sylvian line with perpendicular to Reid's base-line, *R–B*, at pre-auricular point. Sylvian point lies at junction of Sylvian line with line from meatus to 25 per cent. of naso-inionic line.

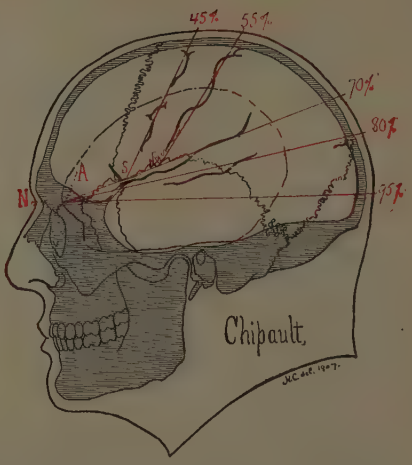

FIG. 91.—Forty-five per cent. of median naso-inionic line = pre-Rolandic point; 55 per cent. = Rolandic point; 70 per cent. = Sylvian line; 80 per cent. = lambda; 95 per cent. gives lower edge of occipital lobe. Line from *A*, external angular process, to 70 per cent. gives Sylvian fissure. *S* = Sylvian point = junction of second and third tenths of this line, while *R''* = inferior Rolandic point = junction of its third and fourth tenths.

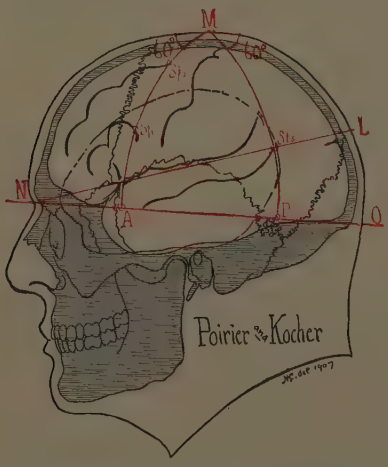

FIG. 92.—*NO* = Kocher's equatorial line, nasion to inion. *NL* = Poirier's Sylvian line from nasion to lambda. *MA* = Kocher's anterior meridian drawn 60° from median line at midsagittal point; lies over precentral convolution and crosses *NL* at Sylvian point. *Sfs* = superior frontal sulcus at one-third of *MA*; *Sfi* = inferior frontal sulcus at two-thirds of *MA*. *MP* = Kocher's posterior meridian, also 60° from mid-line. Lines crossing at *Sts* = superior temporal sulcus.

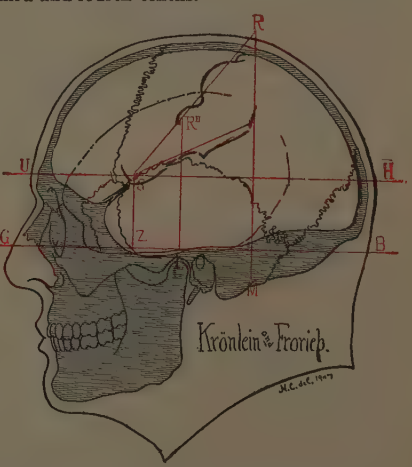

FIG. 93.—*GB* = German "base-line" from inferior edge of orbit through upper edge of meatus. *UH* = upper horizontal, parallel to *GB* through upper border of orbit. *MC* and *Z* = perpendicular at posterior border of mastoid, at condyle and mid-zygoma. The Rolandic line unites the points of crossing of the posterior perpendicular and sagittal lines, *R'*, and the upper horizontal and anterior perpendicular, S. The Sylvian line bisects the angle *R' SH*. Inferior Rolandic point, *R''*.

the nasion to 1 cm. below the lambda (Poirier); or with a line connecting the external angular process with a point 80 per cent. of the distance from nasion to inion (Chipault); or a point 75 per cent. of this distance (Taylor and Haughton); or with a line bisecting the acute angle made by the lines (1) from the superior Rolandic point to the Sylvian point and (2) from the upper border of the orbit and carried

parallel to the base-line (Krönlein); or with a line from the external angular process to a point at the junction of the middle and lower thirds of the line connecting the pre-auricular point and midsagittal points (Anderson and Makins).

The *parieto-occipital fissure* is found opposite to or a little above the lambda, or 6½ cm. above the inion (Thane); or seven-eighths of the distance from the mid-sagittal point to the inion (Anderson and Makins).

Aside from these prescribed rules there are certain general points worthy of observation. The lower level of the temporal lobe—in other words, the floor of the middle cranial fossa—lies about on a level with the zygoma; and the lower edge of the occipital lobe corresponds with the superior curved line of the occipital bone. The Sylvian point, which marks the bifurcation of the Sylvian fissure, corresponds practically with the pterion, and the posterior arm of the fissure in the adult underlies the anterior part of the parietosquamosal suture and ascends to a point just below the parietal eminence; it consequently is much higher than one, not having made measurements, would suppose, for the center of the fissure is fully 2 inches above the zygoma. The motor strip lies more on the top of the hemisphere than on the side and is entirely under the parietal bone; hence diagrams which, on a lateral view, show much more than the face centers—that is, the part below the middle genu—are incorrect and confusing. The mid-point between inion and nasion is easily determined and practically corresponds with a perpendicular erected from the base-line at the meatus. Though this lies 1 or 2 cm. anterior to the superior Rolandic point, a meridian at 60 degrees dropped from this point to the middle of the zygoma, as Kocher has shown, indicates the general direction of the top of the precentral convolution; and this meridian—in view of Sherrington's finding that there is no motor cortex posterior to the central fissure—is as simple and useful a topographical landmark as can be had for general purposes.

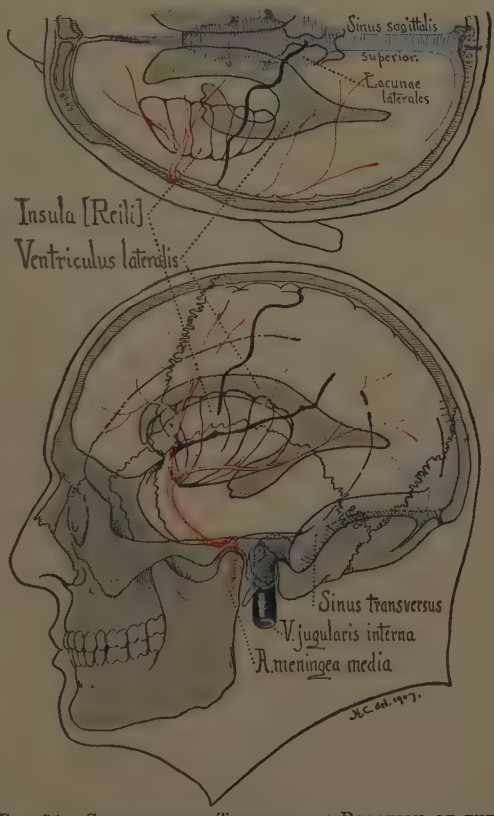

FIG. 94.—SHOWING THE TOPOGRAPHIC RELATION OF THE MENINGEAL VESSELS WITH THE CRANIAL LANDMARKS; ALSO THE SITUATION OF THE INSULA AND THE LATERAL VENTRICLES.

It may further be noted that the Sylvian point marks the pole of the insula; that the parietal eminence overlies the supramarginal gyrus; the frontal eminence, the second convolution; the anterio-inferior angle of the parietal, the inferior frontal

(Broca's) convolution; that the temporal lobe lies for the most part beneath the squamous wing of the temporal bone; the parietal lobe entirely under the parietal bone.

As to *the deeper structures* (Fig. 94), the Sylvian point being the guide to the insula, this in turn covers the basal ganglia, as has been pointed out when speaking of its early formation. The lateral ventricles curl round the basal ganglia with their flat surface on top at a depth of about 5 cm. below the upper surface of the hemisphere. If they are to be approached for aspiration it is desirable to select not only a site where little harm can be done from the passage of the needle, but also where there is the least likelihood of missing the ventricle. Paths of election, therefore, are (1) the superior frontal convolution to the area where the ventricle is horizontally wide over the basal ganglia, or (2) through the posterior end of the superior temporal convolution to the area where the cavity is vertically wide—namely, as it curls around the ganglia and gives off its temporal and occipital cornua.

The *middle meningeal artery* (Fig. 94), after entering the skull at the foramen spinosum, curves forward and upward on the dura, covering the tip of the temporal lobe, to the anterio-inferior angle of the parietal bone, which it deeply grooves or channels. The pterion, therefore, is a guide to the vessel in this part of its course where it overlies the Sylvian point; but for purposes of ligation the vessel can be exposed more safely by trephining in the middle of the temporal fossa where it is easily approached. The attachment of the vessel in the bone at these two fixed points is to be observed in certain extradural operations in the middle fossa, as in the approach to the Gasserian ganglion.

There are various forms of apparatus termed goniometers, cyrtometers, craniencephalometers, etc., usually constructed by fastening together curved metallic tapes which can be placed upon the head and adjusted in such a way as to facilitate the delineation, more particularly of the central fissure. These instruments may be found useful and, as they can be sterilized, it is possible to apply them during an operation. Various designs are obtainable—from Kocher's simple instrument, the purpose of which is limited to angulation with the midsagittal point (Fig. 92), to the more elaborate apparatus of Krönlein, which conforms with the principles of his topographical rules (Fig. 93).

It can be seen that the establishment of the position of the Rolandic fissure has been the chief aim of these investigations—an evidence of the fact that a large proportion of intracranial operations have been directed toward central lesions which loudly call attention to their presence by paralyses or convulsions. However, even in this carefully studied region—the most approachable one for the surgeon—extracranial measurements are not to be implicitly relied upon as guides for the recognition of the central convolutions, and the supplementary acquaintance with actual cortical topography is of far greater importance. Too great dependence on the former may be very misleading. Thus, though the superior Rolandic point can be determined upon the scalp with a small margin of error, this information is not of especial value, for the upper end of the central fissure is so inaccessible, owing to the parasinoidal sinuses, etc., that it can rarely be exposed. Furthermore, the fissure makes such a variable angle with the median line (64 to 75 degrees) and is so sinuous in its downward course, owing to the variable

prominence of the genua, that even though the superior and inferior Rolandic points have been accurately determined, the line connecting them at the prescribed angle (averaging 67 degrees) may lie from 1 to 2 cm. (the width of a convolution) anterior or posterior to that part of the central fissure which is usually brought into view by the operation.

These things are mentioned, not to deter surgeons from studying craniocerebral topography, but rather to point out that topographical delineations on the scalp are at best only a rough indication of cortical landmarks and that the ability to recognize these after exposure in the living is, after all, the essential thing. This presents little difficulty so far as the Sylvian fissure is concerned, and comes with practice in the case of the central fissure, though the final appeal must often be made to faradization. All neurological surgeons, through abundant practice on the cadaver, should acquire so thorough an acquaintance with the precepts of craniocerebral topography that they possess the ability to visualize through the skull not only the surface markings, but also the deeper structures of the encephalon, unaided by elaborate extracranial measurements. They should know the brain as abdominal surgeons know the belly.

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INFLAMMATION OF THE BRAIN.

Acute Encephalitis.—*Polio-encephalitis acuta* (Strümpell).—A more or less diffuse inflammation of the cerebral cortex may occur (*a*) in certain toxic conditions due to gas-poisoning, alcohol, etc.; (*b*) as a consequence of trauma; (*c*) as a complication of such acute infectious diseases as typhoid or influenza; or (*d*) with local suppurative processes, particularly those of the middle ear. The anatomical features of the process are analogous to those which occur in the cord in acute poliomyelitis.

Such an inflammatory process was thought by Strümpell to be the essential lesion in infantile hemiplegia, though it is known that many cases of spastic hemiplegia of infancy may be the result of actual vascular extravasation, such as occurs in cases of dural nevus or in whooping-cough.

The general symptoms are those which accompany all severe acute cerebrospinal affections and are due to tension—headache, somnolence, vomiting, fever, delirium, rapid pulse, and, in some cases of greater severity, choked disk, coma, with slow pulse, and respiratory changes. The local symptoms are variable and depend upon the situation and extent of the lesion. Paralyses may occur or irritative symptoms of

an epileptiform character. Many of these children recover, a large percentage of them being left physically and mentally crippled.

The lesion of encephalitis is usually more marked upon one side and it is especially apt to involve the precentral gyrus. It is occasionally disclosed at operation, especially when this has been undertaken through a mistaken diagnosis of abscess or hemorrhage. Indeed, operative measures may be indicated when intracranial tension, as the result of the process, becomes pronounced. I have once operated upon such a case with the intent of relieving pressure. This patient was a young girl who for several days had been thought to have typhoid fever with cerebral manifestations; a presumable diagnosis of encephalitis was made, and as the pressure phenomena were pronounced, a decompressive operation was performed. It disclosed the characteristic edematous area of softening, dotted with minute hemorrhages.

Voss and Mygind have recently called attention to the frequent association of encephalitis with otitis media, whether disclosed at autopsy, or at operation undertaken for a supposed cerebral abscess. Many of their cases recovered, but whether this was due to the free incisions into the inflammatory area, or whether it would have occurred irrespective of the operation, is uncertain. It has been suggested that the conditions which they describe were nothing more than abscess formation in an early stage, and which would have gone on to suppuration had no operation been done—a view which is opposed to the cases recorded by Strümpell and Oppenheim, in which recovery has ensued without operation.

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Cerebral Abscess.—An abscess in the brain is rarely, if ever, primary, although occasional instances have been recorded in which, even after a most detailed post-mortem examination, it has been impossible to attribut its presence to any external source (Mills and Spiller). It must be appreciated, however, that the lesion may be of such long standing that the original focus of suppuration elsewhere in the body may in the interval have completely healed.

It is usually a secondary process and the three most important causal factors are: (1) *Trauma*, which accounts for 50 per cent. of the cases. We have seen that it is a common sequel of penetrating wounds or fractures of the skull, when infected material of one sort or another has been inoculated directly into the brain substance. Although Bergmann expressed the opinion that it never follows a simple contusion of the head, there seem to be, nevertheless, authentic cases in which,

in the absence of fracture or external evidence of suppuration, such a sequel has occurred (Ehrenrooth). In all probability the blow in these cases has led to a rupture of cortical vessels with extravasation, and there has been a subsequent hematogenous infection of the area of diminished tissue resistance thus produced, the clot proving a favorable soil for bacterial growth. It has already been shown that, in similar fashion, a local suppuration may occur in the cranial vault after a simple contusion; this in turn may lead to a cerebral abscess, often without any definite evidences of intervening meningeal infection. Symptoms of cerebral abscess may not appear until weeks or, indeed, months after a local wound or fracture of the skull has healed. This is especially true of cases in which a foreign body, such as a bullet or a broken knife-blade, has been introduced at the time of the injury.

(2) In *pyemia*, the result of infected wounds, single or multiple abscesses of the brain can occur, but owing to the comparative rarity of this condition in later days they have become a relatively infrequent autopsy finding. Metastatic cerebral abscesses, however, may accompany ulcerative endocarditis, extensive osteomyelitis of the long bones, etc. Their association, particularly with suppurative pulmonic diseases, such as gangrene, empyema, or bronchiectasis, has long been recognized. In 100 cases of pulmonary gangrene Nähter found 8 with cerebral abscess. Abscesses may follow the specific fevers, influenza, typhoid, etc., even without the association of otitis media.

Tuberculous abscesses—the solitary tubercle—are probably always metastatic. They will be considered under tumors.

(3) By far the most important group comprises those which occur from a more or less direct *extension of suppurative disease from the middle ear, mastoid cells, sphenoidal, or frontal sinuses*. As the result of the long-standing suppuration in one of these cavities a gradual necrosis of their thin protecting bony shell may take place. When necrosis has occurred any sudden flare-up in the activity of the disease may lead to involvement of the exposed meninges, and later of the brain itself, particularly if there be any tendency to retention of the secretions due to a cholesteatoma or exuberant granulations. Even with no intervening meningitis, the infection may be carried by thrombosed veins or along lymph-spaces directly into the subcortical tissue.

Focal meningeal abscesses also may occur without a spreading meningitis; they are more commonly extradural, though pial abscesses have been recorded by Randall, Spiller, and others.

The several **modes of infection**, therefore, are: (1) By direct inoculation; (2) by metastasis through the blood stream; (3) by direct extension of the suppurative process from extracranial cavities; (4) by inoculation through infected vessels which connect with an extracranial or extradural suppuration. In the latter instance, as already stated, there may be no visible connection whatever between the original focus and the subcortical abscess—a fact which often enhances the difficulty of the surgical problem. It has been suggested in explanation that the vascular leptomeninges and cortex offer a greater resistance to

bacterial infection than the subcortical nerve tissue, to which the infective material is carried by the capillary lymphatic tubes which traverse the cortex at right angles to the surface and are in direct communication with the subarachnoid space.

Occurrence.—Abscesses of the frontal lobe most frequently follow infection of the frontal sinuses; of the temporal lobe infection in the middle ear or mastoid antrum; of the cerebellum the mastoid cells themselves, either direct or through an intervening sigmoid sinus phlebitis.

According to Grunert, 91 per cent. follow chronic and only 9 per cent. acute otitis media. Partly for this reason adults are more commonly affected. Holt, in his report of 5 cases in infants, calls attention to its presumed rarity in the young. Oppenheim has reported instances of abscess formation after thirty-four and forty-five years of chronic otitis media. I have seen cases after twenty-six and thirty years. In 9,000 autopsies at Guy's Hospital, Pitt found 56 brain abscesses, 18 of them of otitic origin, and only 1 due to nasal suppuration. In La Fort and Lehmann's statistics of 458 cases of abscess, the cerebrum was involved in 227; the cerebellum in 113; cerebrum and cerebellum in 11; pons, peduncles, or fourth ventricle in 7 cases. Thus we see that the cerebrum is affected more than twice as often as the cerebellum. Cassirer has reported 15 cases of the rarer abscesses which occur in the brain stem.

I have seen only 2 cases of frontal lobe abscess. One of them followed a chronic suppuration of the frontal sinus, attributed to a rhinological operation for the removal of a polyp—a not infrequent origin of sinus disease. The other was an acute case secondary to a bullet wound (Fig. 48), the missile having traversed the base of the skull and orbit, opening and infecting the sinus. Neither of these cases recovered. In his study of the cerebral complications of sphenoidal sinus disease, St. Clair Thomson records but 1 case of abscess.

Morbid Anatomy.—Abscesses may be solitary or multiple; diffuse or definitely circumscribed by a capsule; they are occasionally multilocular. The capsule may be rapidly formed (Starr), and the thickness of its walls may reach several millimeters. Abscesses of otitic origin may be bilateral (Whitehead). When multiple abscesses occur they are usually small; isolated ones sometimes reach such a size that they occupy the greater portion of a lobe.

The character of the pus varies greatly, depending upon the age of the abscess. In early cases it is mixed with the reddish débris of disorganized brain matter; in the later cases it is apt to have a greenish tint and a peculiarly disagreeable odor. The bacteriological examination may show a single or a mixed flora. Though staphylococci or streptococci are the ordinary agents of infection, the pneumococcus and still more unusual forms of bacteria may be met with—streptothrix, actinomycosis, the typhoid bacillus (McClintock), etc.

Even when an abscess is directly due to a chronic suppuration of the middle-ear or frontal sinuses it may have no apparent connection

with the original site of disease; in other cases there may be a local or general infection of the meninges. This may occur secondary to rupture of the abscess itself into the subarachnoid space—an incident which is particularly apt to follow a misdirected operation. Lossen has shown that the cerebellum may become infected by extension of suppuration along the sheath of the acusticus; also that cerebellar abscesses are particularly apt to be complicated by sinus thrombosis, meningeal abscess, or meningitis.

Symptoms.—When secondary to a chronic otitis media—and cases of this sort may be taken as typical of all—there appear in sequence certain new symptoms not previously observed. For example.

A patient thirty years of age had had, since an attack of scarlet fever in childhood, a chronic discharge from the right ear. He had had several acute exacerbations of the local disease, none of them serious until the present flare-up of the trouble. Two weeks before his admission there had been an increase in the discharge and some granulations were removed from the meatus. Two days later he complained of some headache and nausea, with fever and chilly sensations (*initial stage*). During the following ten days these symptoms abated somewhat, but did not entirely disappear (*latent stage*). Then, with a sudden cessation of the discharge from the ear, there followed a severe and constant headache, vomiting, a pronounced change in his mental activities, with slowness of thought, drowsiness, irritability, and defective memory. The pulse was slow, his temperature became subnormal, and there was a leukocytosis of 22,000 (*manifest stage*). There were no focal symptoms. Percussion over the temporal bone on the side of the disease elicited marked tenderness. An abscess was found in the temporal lobe, with no evidence of meningeal involvement.

This may be taken as a fairly typical instance of the clinical picture, showing the stages of the disease in their regular succession. When death occurs (*terminal stage*) it is accompanied by high temperature and the usual compression phenomena with respiratory paralysis.

The clinical history is of paramount importance in these cases, for there are no absolutely diagnostic signs. Other than the symptoms thus recorded (the cessation of discharge; the headache, often severe, rarely absent; vomiting; perhaps a chill; often, though not always, a subnormal temperature and slow pulse; drowsiness; irritability; slow cerebration; delirium and loss of memory; tenderness to percussion, etc.), may be mentioned the following: Facial paralysis may occur and be homolateral from involvement of the peripheral nerve itself, or contralateral, together with evidence of compression of the lower precentral area, with aphasia. Occasionally there is contraction of one pupil, followed later by dilatation. A choked disk may develop. Mental symptoms are especially pronounced in frontal lobe abscesses. Change of position is apt to lead to dizziness.

If the acute symptoms subside, if encapsulation take place, and if the abscess be situated in a "silent" region, it may remain dormant for years and only be disclosed by accident at a post-mortem examination. Occasionally when the lesion is situated in the frontal lobe and has led to mental derangement, the victims may become inmates of an asylum and be regarded as chronically insane (Fig. 95).

Even in the presence of suspicious symptoms the seat of the lesion is often most difficult to determine. The best guide, on the whole, is the situation of the external process which presumably has led to it. In abscesses of the temporal lobe, unless they have involved the speech mechanism or the lower motor centers, there may be no localizing symptoms. Abscesses of the cerebellum are particularly difficult to recognize, although suboccipital pain, vertigo, dizziness, nystagmus, or cerebellar ataxia may be suggestive. v. Beck regards a stiff neck

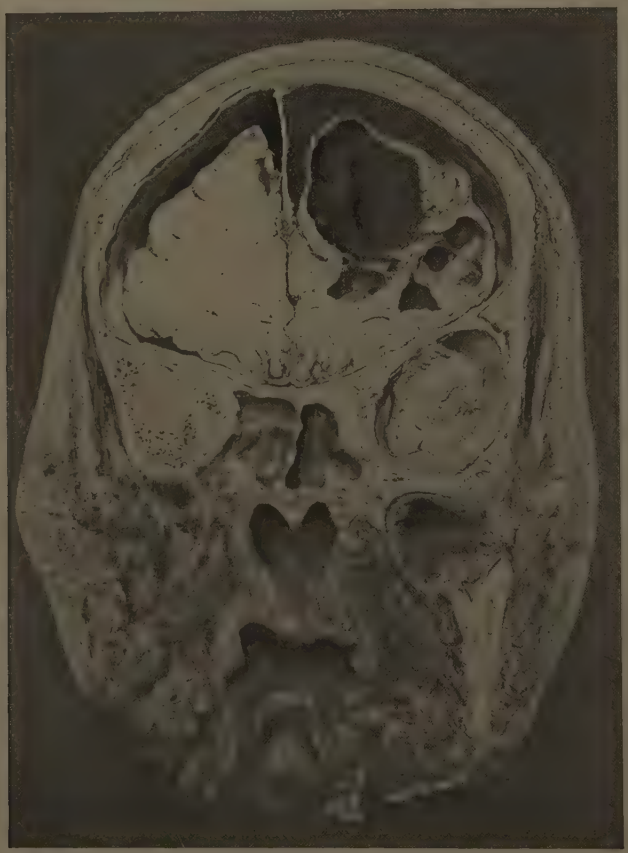

FIG. 95.—LATENT MULTILOCULAR ABSCESS OF RIGHT FRONTAL LOBE. (Kindness of Joseph H. Bryan.)

and turning of the head toward the side of the disease as important. Cerebellar "seizures," which consist of sudden, unexpected attacks of vertigo, roaring in the head, relaxation of the limbs, and falling to the ground in a semiconscious condition (Dana), may be helpful.

Diagnosis.—In the acute cases one must distinguish between abscess, encephalitis, meningitis, ependymitis, and septic sinus thrombosis. When there is no clear sequence of events such as have been described, a certain diagnosis may be impossible. The chronic cases

are not infrequently mistaken for tumors, since they may present the same underlying pressure phenomena.

The history is often of chief importance, for a neurological examination, particularly in the absence of focalizing symptoms, is most unsatisfactory in a patient sufficiently ill to lead to a suspicion of abscess. There are certain points which are helpful in differentiation. The evidences of brain pressure, the stupor, the slow pulse, respiratory changes, choked disk of a low grade, and a subnormal temperature, are apt to be more marked in abscess than in meningitis or encephalitis, except in their late stages. Cervical rigidity and Kernig's sign are more characteristic of meningitis than abscess, and the former usually has a higher leukocyte count (Starr). Sinus thrombosis has a characteristically irregular fever; there is tenderness at the tip of the mastoid and the jugular; exophthalmos follows when the cavernous sinus is involved. There is no history of suppuration in the cases of acute hydrocephalus following ependymal inflammations, and here choked disk appears early and reaches a high grade.

The differentiation between abscess and meningitis may at times be made by an examination of the fluid obtained by a lumbar puncture. The cerebrospinal fluid, even if bacteria are absent, shows an increased number of leukocytes, both in tuberculous and in the early stages of ordinary septic meningitis. This is not true of abscess, unless it be complicated by meningitis. Allan Starr regards this as a valuable aid. Fuchs and Rosenthal have found as high as 952 cells in tuberculous meningitis and 100 in general meningitis; whereas there should normally be but one or two in a centrifugated specimen of 5 cc. Neumann and Grunert found no bacteria in the cerebrospinal fluid. Indeed, in many abscesses of long standing, cultures from the abscess itself prove sterile. There is, I think, always a certain element of danger in a lumbar puncture, since the altered conditions of tension may lead to a rupture of the abscess, particularly if it be cerebellar; only a small amount of fluid, therefore, should be withdrawn.

There are two complications of otitis media which I have found to offer especial difficulties of diagnosis. In one of them symptoms closely resembling intracranial extension of disease may be produced by a reflex disturbance through the trigeminal nerve. These patients show no rise in temperature; but great tenderness, headache, nausea, and even vomiting may occur. The tenderness, however, is superficial and conforms with the trigeminal sensory skin field; even the hair cannot be touched without discomfort. I have seen several cases of this sort recover without operation, and they may possibly represent a mild degree of dural involvement. The other complication, due to an acute serous meningitis (not, so far as is known, of bacterial origin) is still more common and may closely simulate abscess. In these cases a lumbar puncture or a decompressive craniectomy with evacuation of the fluid proves curative; should, therefore, a superabundance of clear fluid be disclosed in an exploratory operation for abscess it is wise not to be too persistent in the search for a pocket of pus.

The **prognosis** without operation is absolutely bad; with operation it is not brilliant. Even in experienced hands the mortality remains about 50 per cent.; for an abscess may not be found, and if it is found and evacuated there may arise unavoidable and often fatal complications—a second abscess due to inefficient drainage, a fungus cerebri, purulent meningitis, septic sinus thrombosis, pyemia, etc.

Treatment.—Most important of all therapeutic measures is prophylaxis. The fact that cerebral abscess is less commonly observed than formerly may be accounted for by the greater promptitude and greater skill shown in the treatment of those diseases whose neglect leads to it. Owing to Macewen's book, which has had a deserved popularity among practitioners in general, rhinologists and otologists are alive to the fact that early radical treatment of suppurating processes, while they remain extracranial, is the best treatment for these intracranial complications. Probably more than one-half of all cases are secondary to suppuration in the otitic and rhinitic cavities, and if they become involved during the course of such infectious diseases as pneumonia, influenza, scarlet fever, typhoid, etc., when patients are seriously ill and unable to call attention to local discomforts, the infection may easily be overlooked.

When an abscess has formed in spite of all care, the condition is serious; a critical operation must be resorted to; and even with our modern methods the mortality remains high. Up to 1884 only 55 cases of operation had been reported (Körner) and Bergmann, in 1889, could find a record of only 8 recoveries. Since Macewen's treatise (1893), however, the operations have so multiplied that they cease to be regarded as rarities. By 1898 there were records of 60 successful operations upon temporal and 12 upon cerebellar abscesses (Marsch). Unfortunately, however, these operations still continue to be conducted as a last resort in the "manifest" or even near the "terminal" stage of the disease. They should, on the other hand, be undertaken early, without waiting for unequivocal symptoms, for, as Körner says, "Auf mehr Zeichen warten, heisst auf mehr Leichen warten."

Method of Procedure.—It is Macewen's opinion that in the otitic cases it is wise, when there is a question of cerebral abscess, to open first of all through the squamous portion of the temporal bone. Otologists, as a rule, owing to their greater familiarity with the method of approaching the dura through the mastoid region and then through the tegmen tympani, favor this posterior route. There is much to be said for both views. The surgeon who is particularly familiar with cranial operations, in case there is some doubt as to the nature of the intracranial complication, might prefer, as a primary measure, to open the skull through the squamous portion of the temporal bone, in order to expose the dura and if necessary the temporal lobe in the middle cranial fossa; for should the exploratory intracranial operation be conducted through the diseased ear, the risk of producing infection would be greatly enhanced. On the other hand, the otologist, after cleaning out the mastoid cells, the infected antrum, and middle ear, is inclined to wait

for a day or two to see whether the suspicious intracranial symptoms do not subside.

I am not convinced which of these methods is the better, and have followed at times one, at times the other; judgment must depend upon the individual case. With experience it is a simple matter to explore intracranially the roof of the petrous bone, the dura overlying it, and, if necessary, the temporal lobe without risk. I prefer to do this by the muscle-splitting operation. In case nothing is found this wound may then be closed—a measure which would perhaps be unsafe if the infected field had been primarily opened up. Particularly in the "initial" or "latent" stages, when diagnosis may be in doubt, the primary mastoid operation is advisable, leaving an open wound. If the suspicious symptoms should continue the opening may be so enlarged and deepened as to remove a part of the tegmen tympani; possibly an extradural focus may be disclosed, or if not, the temporal lobe may be explored with a hollow needle from below. Many successful operations performed by this route have been reported, most of them by otologists. When there is a question of involvement of the cerebellum I think there is no doubt but that this latter method is preferable; namely, to clean out the mastoid cells, antrum, and ear first, and at the same time to investigate the sigmoid sinus. Unless symptoms are urgent the cerebellar exploration may be deferred for a day or two.

When an abscess has been found it should be treated like an abscess elsewhere, with free incision and drainage. It is, however, often difficult to accomplish this, owing to the fact that about the edges of the incision in the brain the cerebral substance becomes edematous, swells, and tends to occlude the opening and retain the discharges. Furthermore, unless meningeal adhesions have formed—and they are unusual—there is a likelihood of meningeal infection as a result of cerebrospinal fluid leakage alongside of the draining abscess. While the brain harbors an abscess it is tense and the exposed cortex tends to protrude through the opening which has been made in the dura: after the abscess has been evacuated this tension subsides and the cerebrospinal space once more opens up and can be reached by the infection.

When, however, adhesions are present and serve to bind together the dura, arachnoid, pia, and cortex, the approach to the abscess may be conducted with a minimum of risk. Owing to the fact that an abscess may assume a mushroom-like shape with a narrow stalk at the original site of infection, it may often be opened through this stalk without doing further damage to the cortex than has already occurred from the disease (Ballance). Preysing's figures well illustrate this type of abscess, and such conditions give a particularly favorable operative prognosis.

In exploring for an abscess it is essential to use a proper hollow needle with a blunt end and with one or more openings, which should be on the side. The brain should be freely incised on a director introduced to the same point at which the pocket of pus may chance to have been

entered. It is well to avoid irrigation of an abscess, though this is a procedure commonly followed. Free drainage is the essential thing, and in the absence of further symptoms the gauze should remain long undisturbed. The patient should lie with the opening downward.

A complication which may arise during the operation, especially when conducted in the "manifest stage" of the disease, is respiratory failure from the additional burden of the anesthetic on an already embarrassed respiratory center. It is essential in these operations, therefore, that an artificial respiration apparatus be at hand, for when put in use it is possible to continue the operation, and if an abscess should be found and evacuated the spontaneous resumption of respiration with recovery is possible. Many remarkable cases of this primary respiratory failure with continuance of cardiac activity have been reported. I have had one patient in whom, though the operation was completed under artificial respiration and an abscess was found, there was no resumption of spontaneous breathing, though the heart continued to beat for twenty-three hours; on another occasion a patient was saved.

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CONCUSSION, CONTUSION, AND COMPRESSION.

These terms, of time-honored usage, are often loosely employed and with but faint understanding, not only of the pathological lesions underlying the conditions so designated, but even less of the physiological phenomena they evoke. They deserve, nevertheless, to be retained and, as is the custom, they will be considered together.

The three conditions shade so imperceptibly into one another that

it is often difficult to determine where true concussion ends and symptoms of contusion begin; and likewise where symptoms of contusion end and those of compression begin. Indeed, in the minds of many, concussion is but a grade of contusion and, furthermore, cerebral contusion is impossible without some degree of compression, whether from hemorrhage or edema, provided the skull is closed and the cranial bones remain intact. A single illustration will serve to show how these states may overlap:

A workingman fell from a scaffold on his head. "Concussion" was evidenced by the immediate loss of consciousness. His failure to recover from this state in the course of a few hours raised a suspicion of "contusion" and free blood would have been found in the arachnoid space. He died in a short time with symptoms of "compression." At autopsy there was found a laceration of the orbital surface of the right frontal lobe with a large extravasation which had forced its way into the brain substance alongside of the basal ganglia (Fig. 96).

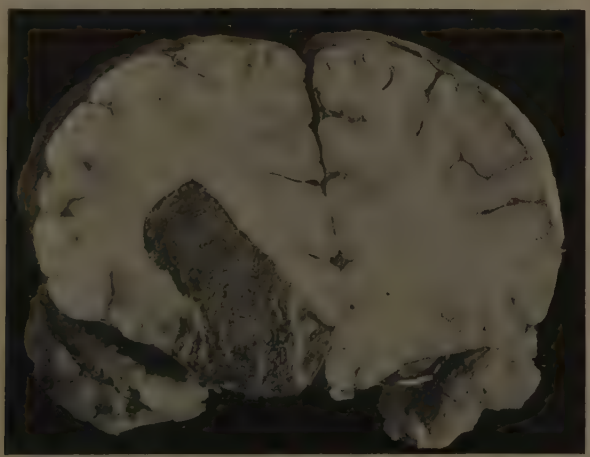


FIG. 96.—BRAIN FROM A CASE OF CONCUSSION WITH CONTUSION AND LACERATION OF RIGHT FRONTAL LOBE AND FATAL COMPRESSION DUE TO LARGE INTRACEREBRAL EXTRAVASATION.

Concussion and contusion are the effects solely of traumatism. The symptoms of compression likewise follow an injury when, as in the case just cited, it leads to intracranial hemorrhage or to swelling of the brain within the closed skull. In its varying grades, however, compression is even more often the result (1) of spontaneous hemorrhage, as in apoplexy; or (2) of edema originating in other than traumatic sources, such as nephritis, or disturbed circulatory conditions of the cerebrospinal fluid the result of ventricular hydrops, or meningeal inflammation; or (3) of the foreign-body effects of an abscess or new growth within the cranial chamber.

Concussion (*Commotio Cerebri; Hirnerschütterung, etc.*).—An individual may be momentarily stunned by a slight blow upon the head. No subsequent ill effects need follow. A more serious blow may lead to an actual temporary loss of consciousness, on recovery from which certain sensations of weakness, dizziness, or headache may persist for a time. A still more violent blow may produce unconsciousness, even

coma, of longer duration, and may leave the victim mentally disturbed for hours or days, with loss of memory of the events connected with the injury; with headache, possibly nausea and vomiting; with ataxia and dizziness, especially when an upright posture has been assumed; and perhaps even with medullary symptoms, shown by slow pulse or respiratory changes. All of these symptoms may endure for days and, in fact, often may leave the patient a permanent victim of post-traumatic neuroses.

Morbid Anatomy.—To what are these symptoms due? Though experimentalists and pathologists have long endeavored to answer this question, they have not done so to the satisfaction of all. Patients in whom serious conditions of concussion have led to death may show at autopsy no cerebral lesion whatsoever. They may at other times show certain foci of extravasation scattered throughout the brain—in other words, microscopic evidences of contusion. These lesions and the symptoms which they produce bear no definite relation to any cranial injury. The skull may or may not have been broken at the time of the injury and, indeed, some of the most serious cases of concussion are

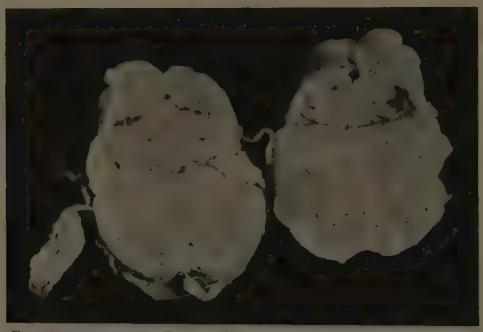


FIG. 97.—SECTIONS OF THE BRAIN STEM SHOWING FOCAL EXTRAVASATIONS. From a fatal case of "concussion" in which no other lesions were found.

unaccompanied by fracture. It is true that most injuries which suffice to cause a fracture are accompanied by symptoms of concussion or contusion, though this is not invariable. Local depressed fractures, for example, can occur without even a momentary loss of consciousness, this being the one cardinal feature of concussion.

The view is held by some that a simple jar of the brain may so disturb the molecular integrity of the nerve cells as to lead to unconsciousness, even to coma and death, and yet produce no lesion which is recognizable, even by a most thorough histological study. As shown by Koch and Filehne, and later by Witkowski, symptoms which are comparable to those of concussion as it is seen in man may be elicited by rapidly repeated blows upon the cranium of an animal—unconsciousness, slow pulse, relaxation of the muscles, insensibility to sensory stimulation, etc. Even should these symptoms be severe enough to result in a fatality, a post-mortem examination may show nothing more than some evidence of hyperemia of the brain and meninges. Fischer believed that the symptoms are occasioned by a reflex paralysis

of the vasomotor center, which leads to a sudden failure in blood pressure analogous to that which occurs in shock.

On the other hand, patients in whom symptoms of concussion have not been severe may die from the effects of concomitant injuries, and, contrary to expectation, the brain may be found at autopsy more or less lacerated and containing scattered foci of extravasation due to capillary hemorrhages. When such extravasations occur in the neighborhood of the pons or medulla they are commonly fatal (Fig. 97). Such findings are naturally classified as contusion.

Upon these different views two schools have grown up: (1) Those believing, with the late von Bergmann, that simple concussion may exist without extravasation, and (2) those agreeing with Kocher in regarding concussion as the result of minute contusions scattered throughout the brain in consequence of the transmitted effects of the blow.

Symptoms.—Disturbances of consciousness are essential to concussion. The victim may be in a simple lethargic state from which he can be aroused, or in the deep sleep of a drunken person. As unconsciousness passes away general evidences of cerebral disturbance appear. There is headache, vertigo, often nausea and vomiting, possibly convulsions, often a subnormal temperature, at times changes in the cardiac and respiratory rates, and almost always more or less loss of memory of the events incidental to the injury. In addition to these general symptoms, inasmuch as many cases of simple concussion are complicated by symptoms due to laceration of the brain and extravasation of blood, focal symptoms may be present.

As indicated in the introductory paragraphs, the severity and the duration of the symptoms of concussion are most variable. In a mild case recovery occurs after a brief interval. In more severe cases, when consciousness has been restored, the patient may perform more or less automatic acts of which he subsequently has little memory, and he may be left for a time incapacitated, both physically and mentally. In still more severe cases profound unconsciousness may endure for a considerable time, during which the reaction to external stimuli is abolished, such as failure of the conjunctival reflexes. The pupils in the early stages are apt to be contracted. There may be involuntary passage of urine and feces. If this condition persists or some hours or days it is probable that, in addition to the concussion, more serious lesions have been produced.

In some instances of concussion a period of excitation may follow the period of depression of the vital functions. The patient may become violent, irrational, and may have to be forcibly confined. An early rise in temperature has been observed in simple cases of concussion. In severe cases it is not unusual for the ten days or two weeks of convalescence to be attended by a subnormal temperature and slowed pulse.

Prognosis.—Any case of cranial injury which results in concussion must be given a guarded prognosis, not only as to the immediate out-

come, but also as to the final restoration of normal cerebral activity. Owing to edema alone, symptoms of compression may supervene in what might have been considered a simple case of concussion; convalescence may be indefinitely protracted, owing to the headache, mental depression, etc., which characterize the familiar post-traumatic neuroses that oftentimes follow such injuries.

Treatment.—A careful examination of the head should be made in view of a possible fracture. In questionable cases it is wise to shave the scalp. Should there be evidence of failure in arterial tension, due to the temporary upsetting of the vasomotor center, efforts should be made to improve the circulation by cardiac stimulants or, better, by measures directed toward supporting the relaxed peripheral vessels, particularly those of the splanchnic field, as by bandaging the extremities or by pressure on the abdomen. The patient should be kept quiet, warm, and his head low. An ice-cap should be applied. Atropin is said to be a desirable drug.

In case the early symptoms have been severe, it is essential that enforced rest and quiet should be continued for a period of from ten days to two weeks, with daily free evacuation of the bowels, an ice-cap, and a light diet. Should a suspicion of further complications arise and especially should pressure symptoms supervene at any time, a decompressive operation is indicated. It may be wise to precede this by a lumbar puncture, which will indicate whether there has been an extravasation of blood or whether the symptoms are simply due to an excess of fluid from edema. In the latter case the puncture alone may often serve to alleviate them.

Contusion.—Concussion, as has been said, may be regarded as nothing more than a low form of contusion, even though there may be no demonstrable evidence of bruising. In case these contusions result in extravasation, macroscopical evidences of hemorrhage may be present, and from these small foci of extravasation we may pass through all grades of contusion up to actual laceration of areas of the brain. Post-mortem examinations after traumatic death occasionally reveal unsuspected lacerations of wide extent, even when symptoms of concussion have been relatively slight. Cases of this sort argue somewhat in favor of a clinical differentiation between concussion and contusion.

Contusions with or without laceration, as pointed out by Duret, are most apt to occur at the tips of the temporal lobe and base of the frontal lobes, a good illustration of which is shown in Fig. 98. These lacerations are a frequent accompaniment of basal fractures, for the same injury which suffices to produce the laceration is likely, at the same time, to cause a bursting fracture of the skull. Contusions often occur at that part of the brain opposite to the point of external traumatic impact, and consequently these cerebral lesions afford a better illustration of the effects of injury by *contrecoup* than do those of the skull itself.

Course.—What has been said of concussion applies likewise to the symptomatology, diagnosis, and prognosis of contusions and lacerations of the brain, though in them the immediate symptoms are usually much more pronounced.[1] The period of "concussion" is longer and certain evidences of compression almost always supervene; early when due to hemorrhage, later when brought about by contusion edema.

Extravasations from the injured vessels vary greatly in number, in situation, and in extent. They may be intracerebral and multiple,

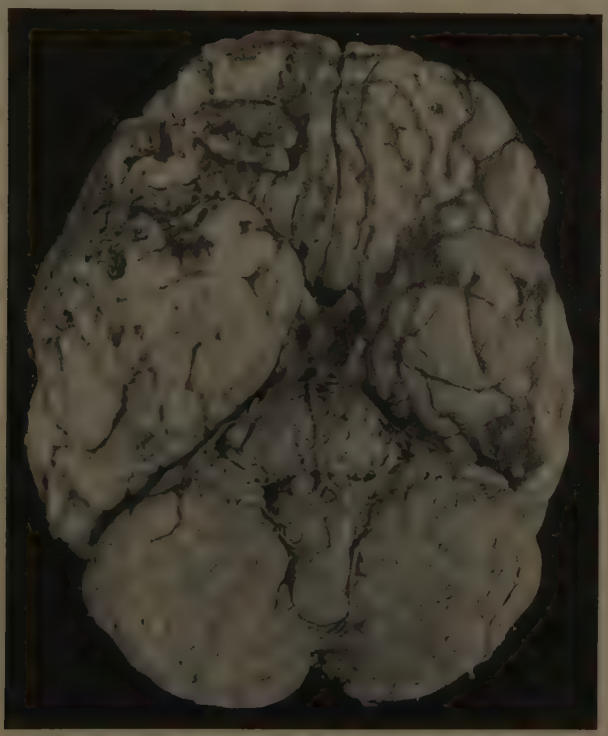


FIG. 98.—LACERATION OF RIGHT FRONTAL LOBE WITH CONTUSIONS OF BOTH TEMPORAL LOBES IN FATAL CASE OF BASAL FRACTURE FROM BURSTING.

and in case they involve important centers may be rapidly fatal without giving symptoms of compression. The only lesions found in a patient, sections of whose brain stem are shown in Fig. 97, were those small,

[1] This is not invariable. I have recently seen a patient who, for nearly two weeks after a fall, had no symptoms other than a slight headache. Major symptoms of compression then appeared, advancing in forty-eight hours to unconsciousness, Cheyne-Stokes respiration, etc. The condition was thought to be what the Germans call *Spätapoplexie*. An emergency decompressive operation was performed. There had been a fracture of the base with laceration of the temporal lobe and a thin, subdural hemorrhage. The acute symptoms were due to a rapid and extensive edema (serous amicrobic meningitis). A large amount of fluid (sterile) under tension was evacuated and the patient recovered.

symmetrically placed foci of hemorrhage. Hence, in contusion there may be no free extravasation into the subarachnoib space.

Most forms of laceration, however, primarily affect the cortex, particularly at the base; consequently the presence of blood in the subarachnoid space is almost invariable, and as this can easily be determined by a lumbar puncture, this measure should become, for diagnostic purposes, a routine procedure in all suspicious cases. At times the extravasation which follows even a small area of contusion may be large and intracerebral, leading to death from compression.

Not only are the symptoms of contusion more pronounced and more enduring than are those of simple concussion, but convalescence as well is more protracted and patients are almost certain to be troubled for some time with symptoms of headache, nervousness, irritability, and mental depression.

Treatment.—As in concussion, enforced rest is essential and should be persisted in for at least a period of two or three weeks. These patients almost invariably reach a certain stage of well-being in which they wish to escape from confinement and resume their work long before they are fit to do so. They are almost always discharged from hospital care earlier than the nature of the lesion justifies. Until there is a complete cessation of headache; until the pulse rate, which is almost always slowed after such a lesion, reaches the normal; until there is a complete disappearance of evidence of intracranial pressure shown by some stasis in the eye-grounds, they must be kept quiet, on a light diet, and recumbent.

Many of the more severe symptoms accompanying contusion may be avoided by properly conducted surgical procedures. Lacerations of the temporal lobe which have led to local intermeningeal extravasations may be greatly benefited by operative measures. When there is doubt about the condition an exploration through the split temporal muscle, with removal of bone, will determine whether or not there is any lesion present; and often the period of post-traumatic edema may be shortened and the symptoms which accompany it lessened by such a measure. It is preferable needlessly to operate on some borderline cases than to neglect those which might thus be benefited.

Compression.—With the exception of a small amount of cerebrospinal fluid, the brain, including, of course, its meshwork of blood-vessels, normally fills the cranial chamber. The cerebral nervous tissue itself is as incompressible as water. In so far, however, as the brain is a vascular organ, it may be made smaller by having some of its blood supply squeezed out through pressure. Thus a foreign body experimentally introduced into the cranial chamber makes room for itself by a local emptying of vessels in the neighborhood, leading to the so-called *local increase in intracranial tension.* The compression effects of such a local disturbance diminish with the distance from the primary seat of pressure, and only in case they are of high degree are they felt throughout the entire chamber. On the other hand, should fluid under pressure be let into the cranium in such a way that it distributes itself in the sub-

dural space through the entire chamber, leading to an equable pressure or tension in all parts, we may speak of the condition as one of *general increase in intracranial tension*. Compression which results from processes of these two sorts must be differentiated. No form of encroachment, however, on the intracranial space fails to affect the cerebral circulation, and it is this circulatory disturbance which plays the chief rôle in eliciting the phenomena of compression.

There are exact clinical counterparts of these experimentally induced conditions. Thus, a tumor or abscess, a focal edema, a vascular extravasation, whether it be outside the dura (Fig. 99) or in the brain substance itself, an operation such as the Gasserian ganglion operation which necessitates elevation and compression of a lobe of the brain, etc.—any one of these things may lead to a local increase of tension, the pressure effects of which diminish in proportion to the distance from

FIG. 99.—TO SHOW MOULD OF LOCAL COMPRESSION OF HEMISPHERE MADE BY AN EXTRADURAL CLOT. Brain hardened *in situ* before removal of calvarium. A displacement of this extent and in this situation could have taken place slowly, as from a meningeal tumor, without involving medullary centers and causing death, as here, from acute compression. (Cf. Fig. 110.)

the local process. On the other hand, in meningitis, in hydrocephalus, in general edema, in widespread basal hemorrhages, or in the congestion secondary to extensive sinus thrombosis, the increase of tension is more general and its effects are exerted in equal degree against all parts of the cerebrum.

Compression, therefore, may occur in a variety of ways; either through the accession of some abnormal substance, or through an abnormal accumulation of some substance already present. Thus, a new growth or an abscess may produce compression, provided the space, which the brain normally should occupy, is encroached upon; either of them may, however, be present and elicit no symptoms of compression in case they destroy the brain as they progress. Again, an increase in the normal amount of cerebrospinal fluid may lead to symptoms of compression in case the fluid is more rapidly

formed than usual or, as in obstructive hydrocephalus, in case it finds unusual difficulty in escaping from the cranial chamber. Edema, the result of injuries or of chemical disturbances in the body fluids brought about by nephritis, may likewise be the source of compression.

The symptoms, however, in many of these conditions, owing to the fact that the cerebral lesions progress slowly, are not exactly comparable with the symptoms which have been produced experimentally; for experimental studies have been devoted largely to the consideration of those phenomena which follow an acute increase of intracranial tension. Consequently the laboratory observations are more directly comparable with clinical cases of acute compression, such as occur in hemorrhage, rather than with cases of slowly progressive increase in tension, due, for example, to tumor.

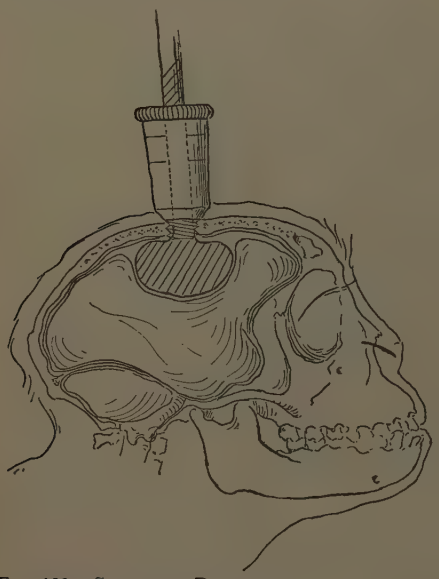


FIG. 100.—SCHEMATIC REPRESENTATION OF HILL'S METHOD OF PRODUCING LOCAL COMPRESSION, AS ADAPTED BY THE AUTHOR.

Physiological Effects of Acute Compression.—Galen, Boerhaave, Haller, Magendie, and many others recorded observations on the symptomatic response to pressure against the brain. In recent times more complete studies have been made by Leyden, Pagenstecher and Duret, by Bergmann, Naunyn and Schreiber, by Spencer and Horsley, Leonard Hill, Kocher, the writer, and many others. A few of the more important factors which have been brought out in the laboratory may be mentioned, in order that we may better understand the physiological responses to compression which we encounter in clinical cases.

It has been emphasized by some that the first effect of any encroachment on the intracranial space is to drive out of the chamber the small amount of cerebrospinal fluid which is normally present.[1] A further encroachment can only occur by crowding out of the blood-vessels a certain amount of their content, and inasmuch as the tension in the cerebral veins is lower than in the other vascular branches, these vessels

[1] This, however, is not invariable, since we often see compression associated with an increase of fluid, as in the acute traumatic edemas—the so-called traumatic serous meningitis. Compression, therefore, does not necessarily mean a "dry brain," for an interference with the normal foramina of outflow for the fluid, by way of the sinuses, may occur as the result of swelling or displacement of the brain with obstruction of these foramina.

are the first to suffer. Venous stasis, therefore, is one of the first consequences of the pressure. A further augmentation of the compressing force, with still greater encroachment on the intracranial space, soon brings the pressure exerted against the brain up to the level of the pressure in the capillaries and even to the arterial tension, and, needless to say, cerebral anemia results, with early and irrecoverable loss of function in those parts of the brain whose circulation has thus been completely shut off for any considerable time.

We must continually bear in mind the difference between a local and a general increase in tension. Inasmuch as the pressure effects of a local process are greater in its immediate neighborhood than at a distance, and inasmuch also as there is considerable pressure discontinuity between the three intracranial compartments, owing to the fairly rigid partitions formed by the falx and tentorium cerebelli, a local pressure (Fig. 100), let us say over one hemisphere, may exceed the local arterial pressure and lead to a local anemia sufficient to throw the adjoining parts of the brain out of function without seriously affecting the other hemisphere or the subtentorial structures, of which the medulla is of prime importance (Figs. 101 and 102).[1] On the other hand, if a compression of like degree had been distributed equally throughout the cranial chamber by means of fluid let into the subdural space under pressure, a generalized anemia would have followed and death would have ensued from implication of the vital centers in the medulla. In a similar way we may produce general compression and elicit the symptoms in their successive stages by pressure on the sac of a cephalo- or meningomyelocele.

As the medullary centers are the crux of the situation, it can be readily inferred that an acute local compression in the neighborhood of the medulla is just as serious as a general compression of like degree; whereas over the hemispheres a much higher grade of local compression is possible without producing death. Thus it is that an arterial hemorrhage (apoplexy) may occur in one of the hemispheres and lead to an absolute local anemia, since the pressure of the extravasation is equal to arterial pressure, without producing a corresponding degree of anemia of the medulla; otherwise all of these cases would of necessity be immediately fatal.

It has been stated that when subtentorial tension—in other words, the pressure against the medulla—reaches the arterial pressure, death must ensue in consequence of anemia of the vital centers. Certain reservations must be made to this statement, for if it implies *normal* arterial pressure it is erroneous. For when the external pressure

[1] A convenient experimental method of exerting local pressure consists of introducing into a trephine opening in the skull a thin rubber bag which can be distended with a known amount of fluid, under a measured tension (Fig. 100). The colored sketches (Figs. 101 and 102) show the effects of local pressure against the right hemisphere which has led to a blanching of the capillaries of the opposite hemisphere (seen through a glass window exactly fitted into a trephine opening) without fatal bulbar symptoms.

against the medulla begins to approach or equal the arterial tension, the anemia stimulates the vasomotor center, the general arterial pressure is raised, and the medullary centers are again sufficiently well supplied with oxygenated blood. If the external pressure is still further raised

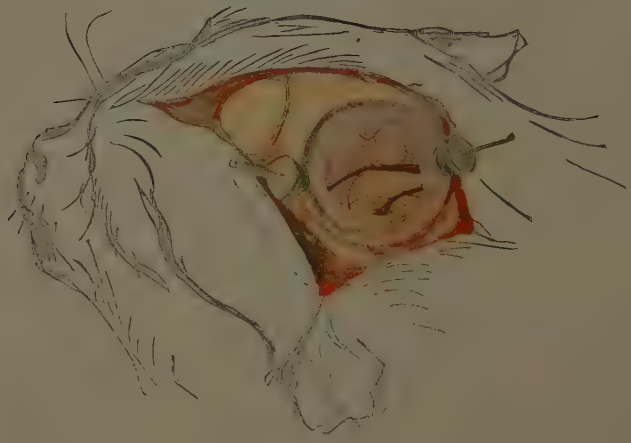


FIG. 101.

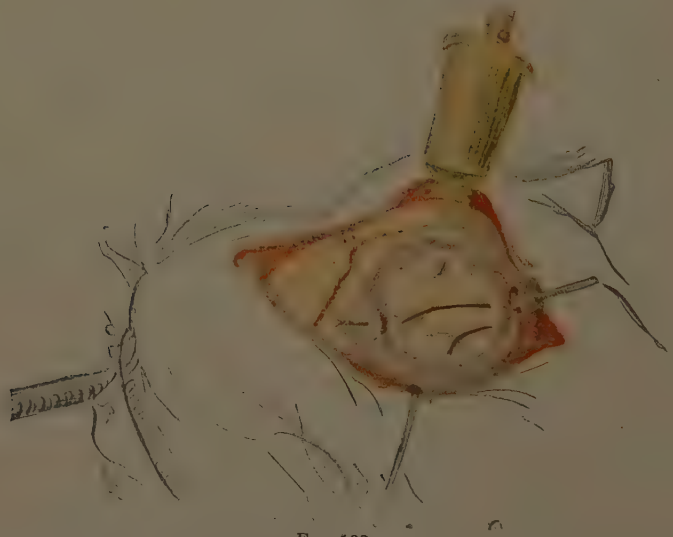


FIG. 102.

FIGS. 101 and 102.—AREA OF CORTEX OF RHESUS MONKEY EXPOSED UNDER WINDOW: SHOWING DETAIL OF VESSELS. (⅔ natural size.)

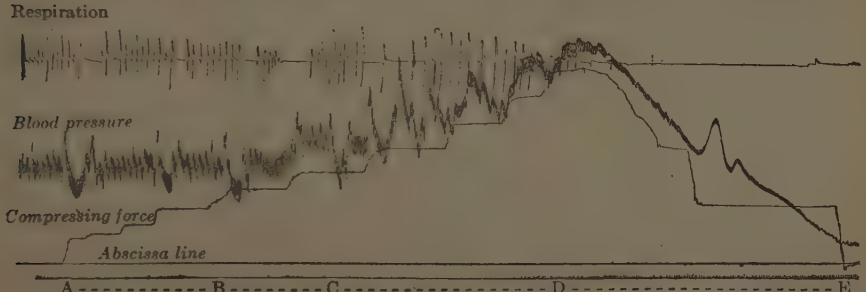
Fig. 101, Before compression; Fig. 102, after local compression (Fig. 100), showing complete anemia with temporary obliteration of arteries.

the same response on the part of the vasomotor center again occurs, and thus in progressive stages the arterial tension may be raised higher and higher until, at times, it may reach more than twice its normal level (Fig. 103).

This progressive rise in tension of the circulating arterial blood, due,

as has been shown, to constriction of the splanchnic field, oftentimes does not permanently continue on the exact level to which it has been forced,—namely, slightly above that of the intracranial tension. On the contrary, it often fluctuates above and below this level, with a definite periodicity (exaggerated Traube-Hering waves), and hence it is that rhythmic respiration of the Cheyne-Stokes type is produced: for during the period of fall anemia results and the respiration fails; when the arterial pressure rises again the medulla is resupplied with blood and respiration is resumed. This reaction (Fig. 104) may continue for hours and has been particularly well described in Eyster's papers.

Finally a time comes when the regulatory mechanism is no longer efficient and then, whether from a further increase in external pressure or from fatigue of the vasomotor activity, the arterial pressure drops permanently below the level of the pressure exerted against the medulla; anemia results, the respiratory center fails, and the heart keeps on beating as an isolated organ, uncontrolled by vagus or vasomotor



A to B, Stage of compensation; B to C, stage of early, though manifest symptoms; C to D, high stage of manifest symptoms; D to E, paralytic stage with failure of respiration and fall of blood pressure.

FIG. 103.—CHART SHOWING RESPONSES TO GRADUAL INCREASE IN INTRACRANIAL TENSION UP TO POINT OF FAILURE OF BULBAR CENTERS.

Pressure removed at D too late to save centers from fatal degree of anemia.

activity, until after a variable time, with fall in pressure to zero, it ceases altogether through asphyxiation.

This brief review of the phenomena, which have been experimentally observed, may suffice to show, as Leonard Hill has emphasized, that compression symptoms are not due to mechanical excitation or structural injury, but, on the contrary, to circulatory disturbances—a primary venous stasis, resulting finally in capillary anemia. It serves also to point out the differences between a local and a general increase in tension: it shows that anemia of the medulla plays the chief rôle in eliciting the so-called major or bulbar symptoms of compression,—namely, the high blood pressure from stimulation of the vasomotor center, the slowed pulse from vagal stimulation, and the rhythmic respiration of the Cheyne-Stokes type which hinges on the fluctuation in level of the raised arterial tension, which for a short period leaves the respiratory center anemic and then resupplies it with activating blood.

Symptoms.—We have seen that compression of the brain can only take place at the expense of emptying certain of the blood-vessels, and

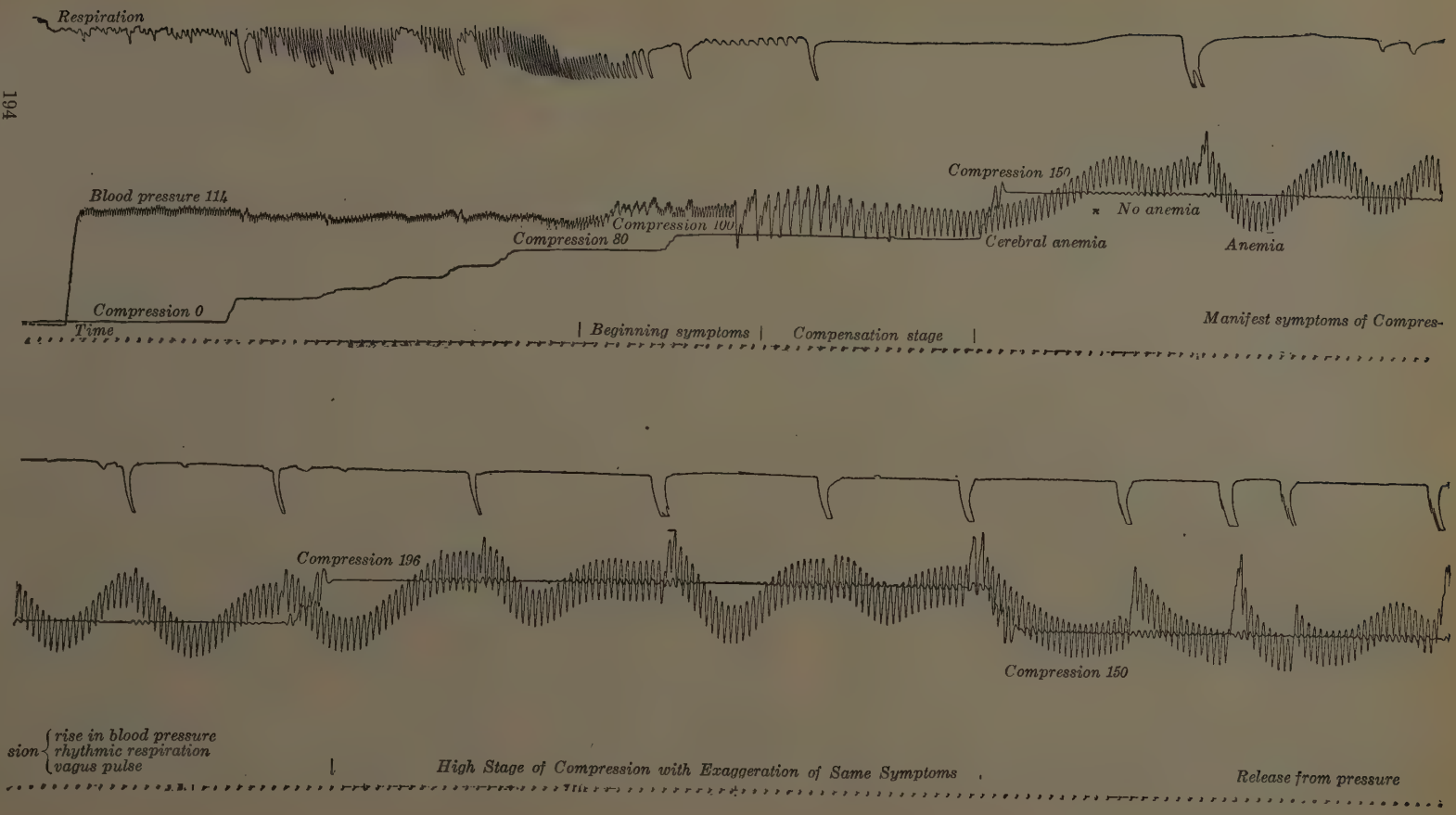

Respiration
Blood pressure 114
Compression 0
Compression 80
Compression 100
Compression 150
No anemia
Cerebral anemia
Anemia
Time
Beginning symptoms
Compensation stage
Manifest symptoms of Compres-
Compression 196
Compression 150
sion { rise in blood pressure
rhythmic respiration
vagus pulse
High Stage of Compression with Exaggeration of Same Symptoms
Release from pressure

FIG. 104.—CHART SHOWING RESPONSE IN RESPIRATION, PULSE-RATE, AND BLOOD PRESSURE DURING EXPERIMENTALLY INDUCED GENERAL COMPRESSION. Intracranial tension increased to 196 mm. of Hg. carrying with it the blood pressure from its normal level at 114 and producing vasomotor waves. Return to normal on release from compression.

furthermore, depending upon the character of the process through which the pressure is exerted, that the interference with the circulation may, on the one hand, be confined to a more or less restricted field or may, on the other, be generalized over the entire cerebrum.

In view of the gradations of circulatory disturbance, as well as of the symptoms they occasion experimentally, Kocher, in his comprehensive monograph, has endeavored to subdivide the progressive phenomena of compression into four stages; and for purposes of clinical designation it is convenient to have such a classification of cases or of stages of the individual case. (The physiological reactions are recorded in Fig. 104.)

His first stage (*Compensationsstadium*) corresponds with a mild grade of compression, or with the early stage of what may become a severe grade, in which the pressure exerted against the brain by the foreign substance is not sufficient to seriously compromise the circulation. By the escape of cerebrospinal fluid and by a narrowing of the venous channels the process is accommodated with nothing more than a certain degree of venous congestion, which may be local. Symptoms are in the main insignificant, particularly if the process is remote from the medulla. There may be some headache, possibly certain focal symptoms referable to the site of the lesion, some mental dulness, and little else. There is but slight interference with the circulation of the brain as a whole.

His second stage (*Anfangsstadium des manifesten Hirndruckes*) corresponds with the beginning failure of circulatory compensation. There is sufficient

venous stasis to lessen the normal amount of blood flowing through a considerable part of the capillary field. Headache is more pronounced and there may be vertigo, restlessness, a disturbed sensorium with excitement or delirium, an unnatural sleep, etc. Other and objective symptoms become manifest, particularly shown as a slight venous stasis of the extracranial vessels. The face appears somewhat cyanotic, the venules of the eyelids are dilated, and of greatest import, a distention and tortuosity of the veins radiating toward the optic papilla, with or without evidence of beginning edema of the nerve head, may be found on an ophthalmoscopic examination. Indications that the venous congestion is affecting the medullary circulation is shown by a slowed pulse and possibly by a slight rise in blood pressure.

His third stage (*Höhestadium des manifesten Hirndruckes*) corresponds with the stage of widespread capillary anemia brought about by further increase of the tension. Here the medulla will not have

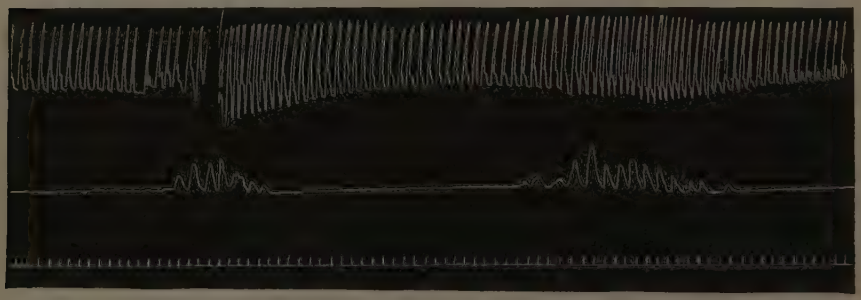


Fig. 105.—Fragment of Record of Pulse Pressure, Respiration, and Time in Second Intervals, taken with Erlanger's Sphygmomanometer from a Case of Intracranial Hemorrhage in the High Stage of Manifest Compression.

Note in upper curve the increase in amplitude of pulse waves showing rise in blood pressure coincident with the return of periods of spontaneous respiration (Eyster).

escaped even though the lesion causing the pressure is a focal one and lies remote from the hind-brain. The period of vasomotor regulation has set in with its high blood pressure, and this, combined with its vagal quality, gives to the pulse its so-called "bounding" character. The rise in arterial pressure may exhibit fluctuations in level, which can easily be recorded on a sphygmomanometer, even when they are not appreciable to the finger.[1] These are accompanied by rhythmicities in respiration, which may acquire the typical Cheyne-Stokes type with periods of absolute apnea (Fig. 105); by rhythmic alterations also in the size of the pupils; by a wavering increase and lessening of the depth of stupor, so that with the "up wave" in pressure, the patient may moan, become irritable, and thrash about, with the "down wave" be deeply comatose; and by other signs indicative of the vasomotor rhythm.

[1] With an instrument of the Erlanger type these rhythmicities in pressure may be detected in some cases even in the second stage of compression, when the vasomotor waves are too slight to be palpated, and when there is no observable alteration in the depth of respiration from one period to another.

The pulse is slowed even to 40 or 50 beats per minute. The choking of the optic disks is more pronounced. The reflexes may become abolished. Cyanosis of the face is extreme, the respiration snoring, and the patient approaches the brink of failure of the regulatory vasomotor responses.

In the fourth or terminal stage (*Lähmungsstadium*) compensation on the part of the arterial tension shows signs of failure; there are irregular cardiac and respiratory efforts, the pulse grows rapid, coma deepens, there is complete muscular relaxation, the pupils become widely dilated, and with the permanent fall in blood pressure (Fig. 103) there is a cessation of all cerebral function with respiratory paralysis.

Prognosis.—States of compression not only vary so greatly in degree, but also may be due to such a variety of lesions that it is impossible to consider fully the course and prognosis of the condition, even as it appears in any single malady. The pressure effects of a tumor or of chronic hydrocephalus, for example, differ materially from those of the acute lesions that have been described. Possibly because they represent asthenic states they do not exhibit the same pronounced responses on the part of the vasomotor center that characterize other and sthenic conditions. The slow progress of the disease may allow of a circulatory adjustment not possible in the more acute lesions, and although a sudden death from compression sometimes befalls these patients, it is apt to be due to paralysis of vital centers by invasion or by a suddenly forming local edema.

In the acute cases, those with hemorrhage for example, the prognosis hinges on the size of the compressing mass, the rapidity of its formation, the length of time which has elapsed, and the stage of compression which is reached. A patient in the third stage, with high blood pressure, and especially when respiratory difficulties with snoring or rhythmic alterations are in evidence, must be regarded as in a most precarious condition. For, even though the pressure may not advance and though the vasomotor mechanism suffices to tide over the threatened medullary anemia, there is always a chance that an inhalation pneumonia may follow.[1] The immediate prognosis for life in all cases which do not reach the "high stage of manifest compression" is good, although the extent of damage from the local lesion, whatever it may be, may suffice to leave incapacitating paralyses. This, however, is another story, to be taken up with the consideration of the various lesions which produce compression.

Treatment.—Only certain general rules can be laid down; the more specific ones must be deferred for other sections. Needless to say, we must meet with mechanical measures a condition—viz., pressure—which is produced by mechanical forces. This means, on the one hand, a removal of the source of pressure, be it an accessible clot or abscess, a tumor or increase of cerebrospinal fluid; on the other hand, a release from the effects of the lesion by an opening in the skull—a decom-

[1] This was the ultimate cause of death in 3 of the apoplexy cases on whom I have operated in an advanced stage of compression; a fourth has recovered.

pression, in other words—in case the lesion is inaccessible or is irremovable, as in edema, etc. The surgical methods of accomplishing these results will be considered elsewhere.

There are two other measures seemingly less radical than a cranial operation; both of which have their advocates, both of which possess elements of danger—lumbar puncture, with the idea of making room by removing fluid, and venesection, with the purpose of lowering the high blood pressure and of "depleting" the brain. In cases of compression of high grade a lumbar puncture may be promptly fatal, owing presumably to the fact that the intracranial pressure wedges the medulla and lips of the cerebellum into the foramen magnum when the support of the spinal fluid has been removed. (Cf. Fig. 118, p. 222.) Numerous sudden fatalities have been recorded as a result of this measure.

Venesection, particularly in cases of compression from hemorrhage, has been considered advisable, on the view that the high arterial pressure is the cause of the hemorrhage and is likely to increase the bleeding, rather than that it represents a conservative process on the part of the organism to overcome cerebral anemia. Falkenheim and Naunyn recommend that the blood-pressure should be supported by every means in these cases. Bergmann and Hill, on the other hand, are inclined to the traditional treatment of lowering it by blood-letting. It has been my experience, both in the laboratory and clinic, to see disastrous results from venesection with lowering of blood pressure in cases of compression in its third or highest stage. Only in cases which rest in the earlier stages, with an abundant reserve on the part of the vasomotor center, can blood be withdrawn with impunity, and in these cases there is rarely any symptomatic indication for bleeding.

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INJURIES AND DISEASES OF THE CEREBRAL BLOOD-VESSELS.

Intracranial Hemorrhages.—The symptoms of intracranial hemorrhages are necessarily so associated with those of concussion, contusion, and compression of the brain that it has seemed wise to defer until this time the discussion of all forms of bleeding within the skull. A single exception has been made in favor of those forms which occur in the newborn. Pachymeningitis hæmorrhagica has also been considered elsewhere.

The extravasated blood may be found between the skull and dura, between dura and arachnoid, in the subarachnoid meshwork, between pia and cortex, and finally as a true cerebral hemorrhage, whether superficial or deep, in the brain substance itself.

Extradural Hemorrhage (Hematoma of the Dura Mater; Meningeal Apoplexy.—*Etiology.*—An extravasation between dura and bone, though usually of arterial origin, may result as well from an injury to the veins, sinuses, or parasinoidal sinuses. The dural vessels may have been injured by punctured or perforated wounds; by simple linear fractures; by depressed fragments of bone in a comminuted fracture; or even by a deformation of the skull without fracture. If, owing to the character of the injury, the dura itself has been lacerated, as well as some one of its vessels, bleeding may take place underneath the membrane; or if there is an external wound in addition, the blood may find its way outward, and thus an extradural hematoma need not form. Likewise in depressed fractures, even though the fragments have torn an arterial branch, they may be so wedged against the vessel as to prevent extravasation, and serious bleeding often does not occur until an operative attempt has been made to elevate the fragments.

Injuries to the venous sinuses, from wounds or fractures, providing the lesion is confined to the outer surface alone of the sinus, may lead to an extradural extravasation. Owing to the low tension of the venous blood, however, it does not succeed of itself, as does an arterial extravasation, in stripping the dura away from the bone; hence, unless some separation of the membrane has occurred as a direct result of the injury, a dural hematoma from this source is rare. The most common extradural hemorrhage of venous origin is met with as a post-operative complication of craniotomies; for, after the replacement of an osteoplastic bone-flap, dura and bone having been separated during the operation, an extravasation from slow venous oozing may take place, and, unless the wound be opened and the clot removed before pressure symptoms are marked, such an extravasation may lead to serious consequences (Fig. 106).

It may be noted that in cases of death from extensive burns extradural clots have been found at autopsy, not to be accounted for by any cranial injury.

A fissured fracture, the line of which crosses one of the meningeal vessels as it lies in an anatomical groove in the bone, leading to an arterial extravasation, is the more common source of a dural hematoma

(Fig. 107). Though usual, a fracture is not essential, for the vessel may be torn in consequence of cranial deformation alone without any actual rupture of the cranial wall. In some cases the extravasation may take place by "*contrecoup*," on the side of the head opposite to that which receives the blow; and, indeed, there may be a bilateral extravasation.

Only when the cranial injury has been of such a nature, however, that the dura has not been torn do the symptoms of this lesion assume their peculiar and characteristic sequence. Consequently, the meningeal hematomata which accompany more serious forms of injury, when the bleeding escapes externally through an open wound or under the dura through a laceration in the membrane, need not be considered apart from intracranial hemorrhages in general.

FIG. 106.—POST-OPERATIVE EXTRADURAL HEMATOMA FROM SLOW VENOUS OOZING. Bone flap re-elevated forty-eight hours after operation, owing to symptoms of compression.

Seat.—Being usually the result of a laceration of the middle meningeal artery, the large majority of extradural hematomata occur under the lateral aspects of the skull and more particularly in the temporal region. The extravasations also are more or less circumscribed, for only when one of the main branches of the vessel or the trunk itself has been injured will there be a widespread escape of blood. The terminal twigs of the artery, inasmuch as they do not deeply groove the bone and have but slight communication with its inner surface, are rarely the source of extensive bleeding.

Krönlein has given three chief seats for these extravasations—an anterior, middle, and posterior—in correspondence with the particular branch of the artery which has suffered injury, and has indicated in his familiar diagram (Fig. 108) points which he considers elective ones for

trephining. An extradural hemorrhage, however, may be difficult of diagnosis; to decide upon which side it has occurred is oftentimes more so; to determine the particular branch of the vessel which has been injured may be well-nigh impossible. Hence, when a lesion of the meningeal artery is suspected it is wise to select the middle ground over the main trunk for exploration; and if focal symptoms have not been

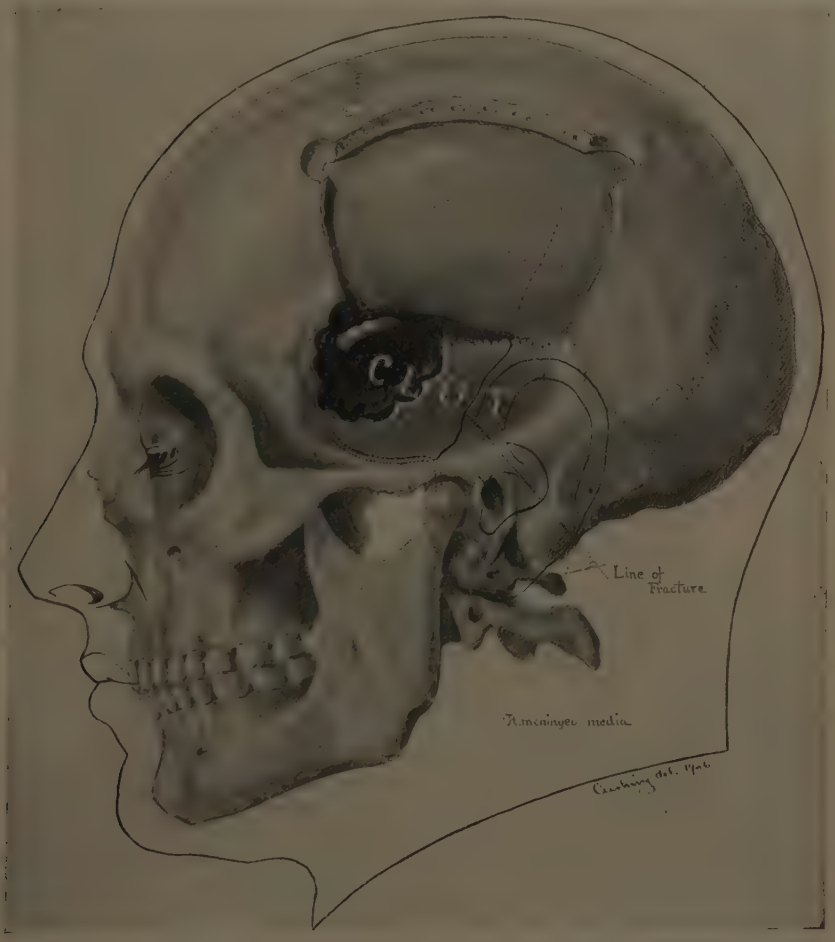

FIG. 107.—CASE OF BURSTING FRACTURE OF THE SKULL IN WHICH THE FISSURE LACERATED A. MENINGEA MEDIA AT FORAMEN SPINOSUM.

Note low-lying clot not exposed by misplaced osteoplastic flap and necessitating further opening with rongeur forceps.

clear, a bilateral exploration may be called for. As in a case which I have recently reported, the main stem at its point of entrance through the foramen spinosum may have been injured (Figs. 107 and 109).

Extradural hemorrhages, however, may take place elsewhere than over the middle meningeal territory, even without any gross lesion of the cranial vault. Thus, they not uncommonly occur in the occipital

fossa, and one of the cerebellar lobes may become compressed from such an extravasation just as may one of the hemispheres. They may occur also in the frontal region as a result of cranial deformation alone without fracture. In one of my patients, with no demonstrable fracture, a large symmetrically placed frontal extravasation was found, amounting to 230 cc. of blood; the bleeding apparently originated from torn emissary vessels which connected the longitudinal sinus and calvarium.

Form.—The hematoma may be thinly spread out or, on the other hand, may be circumscribed and thick. In its typical form it is more or less circularly lens-shaped. As it extravasates, the blood quickly

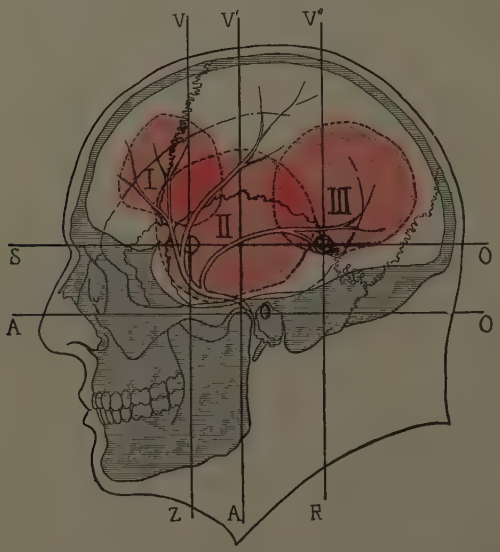

Fig. 108.—Krönlein's Scheme for Finding Points of Election (Circular) for Trepanation in Meningeal Hemorrhage.

Also three usual sites of extravasation, *S–O*, linea horizontalis supra-orbitalis; *A–O*, linea horizontalis auriculo-orbitalis; *V–Z*, linea verticalis zygomatica; *V'–A*, linea verticalis auricularis; *V''–R*, linea verticalis retromastoidea.

clots and the disk-like hematoma (Fig. 110), being constantly added to at its central point, leads to the gradual stripping away from the bone of the more or less firmly attached membrane. It is probably this continuous increment to the ever-thickening center of the clot which furnishes pressure directly against the membrane sufficient to separate it from the skull. The adherence of the dura differs greatly at different ages, it being more firmly attached in the extremes of life. Consequently these extradural hemorrhages are much less likely to occur in infancy and advanced age. The amount of the extravasation varies greatly in individual cases, and it is astonishing how large a clot may at times be accommodated by the compressed brain before fatal pressure symptoms result. The occurrence of serious symptoms depends partly on the situation of the clot; partly on its tension—whether it be due to arterial or venous extravasation; and partly on

its size. Clots of from 4 to 6 ounces are not uncommon, and even larger ones have been recorded. Rarely, however, may the hematoma reach such a size and be compatible with a continuance of circulation in the medulla.

Symptoms.—They naturally show considerable variability, depending on the situation and size of the clot and the rapidity of its formation. One feature, however, often serves to distinguish them from all other forms of intracranial hemorrhage—the so-called "*free interval.*" As a rule, the injury which has led to the vascular lesion has been sufficient

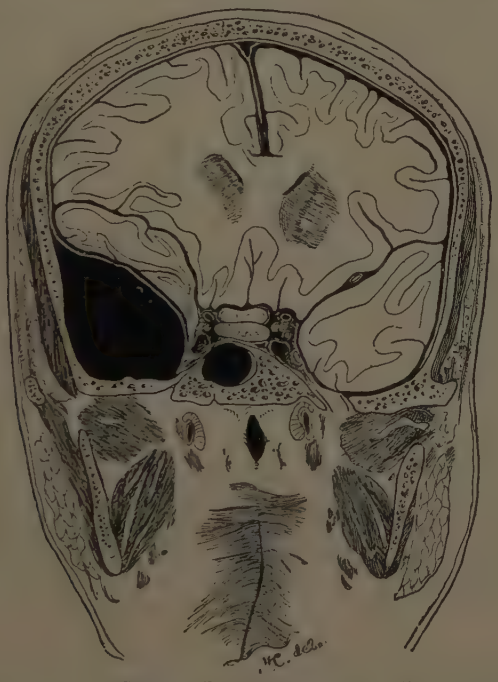

FIG. 109.—CORONAL SECTION, PASSING THROUGH THE PITUITARY FOSSA.
To show the situation of the extradural hematoma in a case of injury of the meningeal at the foramen spinosum.

at the same moment to so stun the patient that some grade of unconsciousness from concussion has been produced. These primary symptoms due to concussion may pass away in the course of time and the patient's mental activity become in a degree restored. Then, after a few hours of relative freedom from evidence of marked cerebral disturbance, headache and possibly vomiting appear, and in a short time the patient again sinks into a stuporous condition. Before this has occurred, however, should he be under close scrutiny focal symptoms may have been observed.

These *focal symptoms* are as important in determining whether the extravasation is right or left as the free interval is important in determining whether it exists at all. They are commonly irritative, shown

by twitching of the face or arm; for, owing to the usual situation of the hematoma, the centers at the lower end of the Rolandic strip are most likely to feel the pressure effects of the clot. In left-sided lesions motor aphasia is also a characteristic sign. These evidences of irritation may advance to local paralyses of the same centers—a sequence of events which may be observed before the patient loses consciousness and before general symptoms of such a nature appear that they are entirely masked in the more profound phenomena of compression.

Instances of actual hemiplegia from an extradural hemorrhage have also been recorded, but they must be rare, since the centers for the lower extremity lie so far away from the primary point at which an extravasation of this sort is likely to arise, that a clot large enough to implicate the upper ridge of the hemisphere would, in all probability, either lead to such deep coma that symptoms of hemiplegia could not

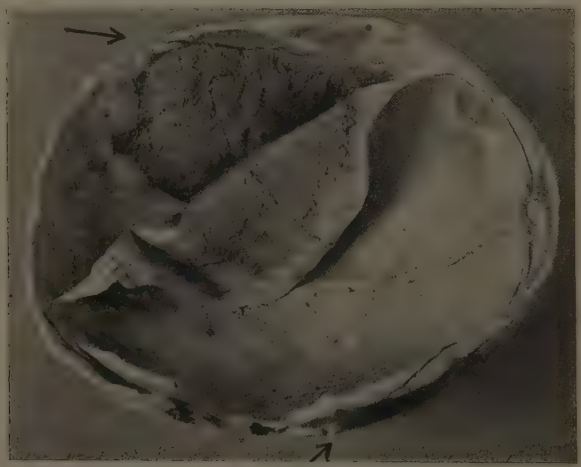

FIG. 110.—PHOTOGRAPH OF CALVARIUM WITH DURA REFLECTED SHOWING EXTRADURAL CLOT GROOVED BY THE MENINGEAL ARTERY, WHICH HAD BEEN TORN BY THE LINEAR FISSURE. From a fatal case of meridional fracture. Arrows indicate lines of fracture. Compare with brain of same patient (Fig. 99, p. 189).

be appreciated or else would cause death before they were apparent. More rarely evidences of sensory disturbances, whether subjective or objective, may be elicited before the patient has become lethargic.

Other focal signs may become apparent. Thus, pupillary symptoms, particularly inequalities, are common in this as in other forms of unilateral intracranial hemorrhage. The pressure of the clot against the hemisphere is said to cause an early narrowing of the pupil on the same side and, later on, a dilatation. This dilatation in the late stages may affect both pupils, but even then the pupil on the side of the lesion remains the wider. Changes in the eye-grounds are also common and should always be looked for. Tortuosity of the veins and edema, indicating an early stage of choked disk, due to the intracranial stasis and usually appearing first upon the side of the lesion, is the most delicate and valuable of all objective signs.

These focal symptoms may be fleeting—a matter of a few hours; their duration depends entirely upon the rapidity with which the hematoma is forming. They are usually followed by symptoms indicative of general pressure, by stupor, unconsciousness, a slowed pulse, a rise in blood pressure, respiratory symptoms, and other evidences of implication of the medulla in the general disturbance. In some cases there is a considerable rise in temperature.

It must be borne in mind that the absence of focal symptoms and the non-appearance of a free interval does not necessarily exclude the presence of an extradural hemorrhage. For, instead of there being a simple concussion as a result of the primary trauma, contusion of the brain may have occurred, with rapid extravasation of blood beneath the dura. Under these circumstances the primary symptoms of concussion would shade off into those of compression with no evidence whatsoever of an "interval" marked by improvement in cerebral symptoms. Furthermore, there are certain rare cases in which the cranial injury may be of such a nature as to lead to a rupture of the meningeal; and after what may be termed a free interval—though preceded by no stage of primary concussion—symptoms indicative of an extradural hemorrhage may occur. Such a case I have recently recorded—one in which, instead of by a blow with consequent concussion, the cranium was deformed and fractured by being squeezed between two heavy bodies.

When typical symptoms are present an unequivocal *diagnosis* may usually be made. Only in the complicated cases and in those lacking the cardinal symptom of a free interval do uncertainties arise. An exploration may often be necessary before it can be determined whether there is an extradural or intradural hemorrhage. The presence of bloody fluid in the lumbar arachnoid, though pointing to the latter, does not necessarily exclude the former. It is often difficult also to determine upon which side of the head the hemorrhage has occurred. Even if focal symptoms are present they may be confusing. Thus, it is sometimes impossible to tell whether pressure upon the cortex has led to paralysis of the face or whether it is due to a peripheral lesion of the facial nerve on the same side, owing to its implication in a fracture of the base. Similarly, dilatation of the pupil may be of cortical origin or due to peripheral involvement of the motor oculi. The clot may be so low (Figs. 107 and 109) that it does not involve the motor area; or, on the other hand, it may be situated directly over it (Fig. 99) and lead to focal paralyses from local anemia.

Prognosis.—From the study of a large number of records it is estimated that 90 per cent. of these meningeal apoplexies prove fatal if unrelieved surgically, 60 per cent. of them dying within the first twenty-four hours. Of a large series of operated cases 67 per cent. recovered—a percentage which would be much larger were it possible to secure prompt intervention before the onset of medullary symptoms in those patients in whom the extravasation takes place rapidly.

Treatment.—Inasmuch as most of these cases when treated expec-

tantly terminate in death and inasmuch as when operated upon they furnish possibly the most satisfactory results of all cranial cases, it is wise to explore whenever the diagnosis is in doubt. A carefully conducted exploration cannot be harmful in cases of intracranial bleeding from other sources and may be curative when it is extradural.

Much has been written in regard to methods of exploration and to the treatment of the injured vessel when an extradural clot has been found. The important thing is to find the extravasation; and this should occasion no great difficulty when it has reached a size sufficient to cause serious symptoms, provided the wrong side of the cranium has not been entered. The precise measurements given by Krönlein to determine fixed points at which the trephine should be applied do not seem to me to be especially serviceable. The essential thing to bear in mind is that the main stem of the meningeal runs across the middle of the temporal fossa (Fig. 94) and branches near the pterion or, roughly speaking, to use Vogt's rule, at a point two fingers' breadth above the zygoma and a thumb's breadth behind the vertical process of the malar. Consequently an approach in this situation will expose the main stem and in the majority of cases enable one to ligate the vessel if an extravasation has been found. The passage of a blunt spatula toward the frontal, middle, and posterior divisions of the vessel will serve to expose a clot, should one be limited to either of the three zones described by Krönlein.

Krause advises an approach through an osteoplastic flap similar to that which he uses in his Gasserian ganglion operation. This flap will almost certainly expose the necessary field and is preferable, I believe, to Krönlein's trephine openings. Still better, it seems to me, is the intermusculotemporal operation which I have described, for it is much less of an undertaking than the formation of a bone flap. An incision should be made through the muscle separating the fibers. They should be held apart and an opening made through the thin cranial wall of the temporal region. This may then be enlarged in any direction to the extent which seems necessary. The meningeal is exposed and its branches may be easily reached by a blunt instrument. In case a clot is found it can be scooped out and the main trunk of the vessel itself be ligated if necessary. Through such a split-muscle opening drainage can be more easily used than after a bone-flap operation. Furthermore, the intermusculotemporal operation is so simple that a bilateral opening can be safely made in case no clot has been found on the side first opened.

Subdural Hemorrhages.—Bleeding in the free space between dura and arachnoid is possibly a more common consequence of injuries than the extradural form. It is a frequent complication of basal fractures; for, owing to the close attachment of the basal dura, these injuries almost always tear this membrane so that the bleeding from the fissured bone has free access to the subdural space. Similarly, fractures of the vault, accompanied by laceration of the dura, lead to extravasations over the hemispheres. The extravasation, however, may occur from an injury

of some cortical or leptomeningeal vessel in cases of fracture with laceration of the brain or, indeed, in the absence of any demonstrable cranial lesion.

The usual type of extravasation is a diffuse one, particularly in its basal form. The blood spreads freely through the open subdural space, and as it often happens that the arachnoid membrane overlying the basal cisterns has been torn by the injury, the bleeding extends over the brain stem and down along the cord, where the subarachnoid space is open and not a closely confined meshwork as it is over the hemispheres. Hence, a lumbar puncture will often disclose free, red blood-corpuscles in the cerebrospinal fluid.

Although this diffuse form of bleeding is perhaps the most common as well as the most critical type of subdural hemorrhage, one not uncommonly sees, particularly over the hemispheres, extravasations in this space which have remained circumscribed owing to rapid clotting of the blood. Subdural extravasations are usually of venous rather than of arterial origin.

The *symptoms* of a subdural hemorrhage differ in no great respect from those associated with an acute increase of intracranial tension from any cause. Although in the rarer cases of circumscribed and superficial clot formation there may be localizing signs pointing to the seat of the process, the symptoms are usually those of a generalized compression. The lesion, as a rule, results from a serious cranial injury, and the clinical picture is one of cerebral contusion with compression. The patient is unconscious, medullary symptoms are almost invariably present, the blood pressure is high during the early stages, the pulse slow, the respiration labored, and as stupor passes into coma—unless the progress of the extravasation be interrupted or its pressure effects relieved—rhythmic breathing of the Cheyne-Stokes type sets in, and finally the paralytic stage of compression supervenes. It is due to free extravasation of this sort into the subdural space that most forms of basal fracture prove fatal. Occasionally the amount of the extravasation may be slight, and although the cerebrospinal fluid, as shown by lumbar puncture, is bloody, the extravasation may not be sufficient to produce serious pressure symptoms.

A choked disk of varying degree is almost always present in these cases.

The *diagnosis*, as a rule, is less difficult than in extradural hemorrhages, although until an operation has been performed or the presence of the bleeding is shown by lumbar puncture, it must be somewhat conjectural. It is safe to say that in any serious cranial injury in which unconsciousness has been present from the first, subdural bleeding is taking place, either from the fracture itself or from some laceration of the brain. Confusion may arise in certain cases, owing to the fact that acute, traumatic cerebral edema may closely simulate the general pressure phenomena which accompany actual extravasations of blood.

The *treatment* is as satisfactory as the treatment of extradural hemorrhages, in case the extravasation has occurred over the hemi-

sphere and has remained more or less localized. I have seen a patient injured in a football scrimmage, in whom an actual free interval occurred after a primary concussion, and in whom focal symptoms pointed toward a local compression over the lower central convolution on the left side. It was naturally supposed to be an extradural hemorrhage. An intermusculotemporal operation was performed; no demonstrable fracture of the bone was found, and there was no bleeding outside of the dura, but underneath there was a lens-shaped clot exactly comparable to an extradural hematoma, removal of which led to prompt recovery. Cases of this sort, however, are rare, and the surgeon is usually confronted with extensive basal extravasations.

There is a difference of opinion not only as to the advisability of operating in the presence of a basal fracture with diffuse hemorrhage, but also as to the method to be employed in case it is decided to intervene. One cannot hope to disclose the point of injury or to check the oozing which may be taking place, but the chief indications in the face of compression symptoms are to bring relief by decompression and to furnish a means of escape for the extravasating blood. When the pressure phenomena have not advanced to the point of seriously implicating the bulbar mechanism—in other words, when circulatory compensation is acting properly—an expectant treatment may be resorted to. If, however, there is evidence of threatening failure in this compensatory mechanism, it is inadvisable to delay intervention.

The simplest method of approaching the base should be followed, especially as a bilateral operation may be called for. For this reason bone-flap operations, in my opinion, are somewhat too complicated for these cases, and do not allow of the satisfactory placement of a drain. Inasmuch as the middle fossa of the skull is the one usually implicated, and inasmuch as the thin bone over the temporal region not only is easily entered and rongeured away, but also since a bone defect thus produced is best protected subsequently, a route through the temporal muscle is preferable to any other. It must be borne in mind that in these cases the brain is under more or less tension and, furthermore, is often lacerated, so that, with a torn pia-arachnoid, a cerebral hernia and perhaps a fungus cerebri is likely to occur should a bone defect, especially one carrying a drain, be protected by scalp alone. For this reason it is most desirable to have such a traumatic hernia protected by muscle, and it can best be accomplished in this way. My usual plan of procedure after splitting the temporal muscle and entering the skull low down at the side of the middle fossa is to open the dura and by blunt elevation of the temporal lobe to withdraw as much of the bloody cerebrospinal fluid as possible. If bleeding is continuous protective rubber wicks should be introduced under the temporal lobe and be led out through the intermuscular incision at its lowest angle. The remainder of the split muscle and of the skin may then be closed. It may often be necessary to perform a bilateral operation of this sort in case the first opening has not sufficed to relieve the pressure symptoms. In this way a number of these surgically difficult cases may be saved provided

they are not allowed to progress until they approach the paralytic or terminal stage of compression and in case laceration of the brain has not been extreme.

Subarachnoid Hemorrhages.—When free hemorrhages occur in the subarachnoid cisternæ about the brain stem, implication of the bulbar centers is usually so rapid that fatalities occur before there is any possibility of surgical intervention. When, however, they are limited to the spaces over the hemispheres, the extravasation is checked and often merely infiltrates the subarachnoid meshwork (Fig. 111). Hemorrhages in this situation are due either to contusions or lacerations of the brain substance itself, with rupture of some of the vessels which pass freely through the subarachnoid spaces, and they are often associated with subdural or even with extradural extravasations.

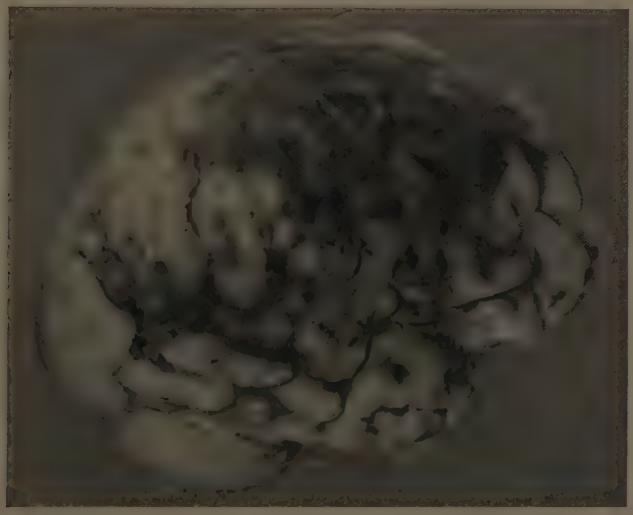

FIG. 111.—BRAIN OF A CHILD SHOWING SUBARACHNOID INFILTRATION OVER BRUISED HEMISPHERE; THE RESULT OF A FALL WITHOUT CRANIAL FRACTURE.
Death in forty-eight hours from compression due to edema. No operation.

Aside from the fact that they accompany conditions which call for surgical intervention for the relief of pressure, these diffuse extravasations in themselves can only be afforded an outlet by the unsatisfactory pricking of the membrane in various intergyral areas.

The picture of such hemorrhages disclosed at operation is a striking one, owing to the cherry-red color of the hemisphere, covered as it is by the infiltrated subarachnoid spaces. When such extravasations are unaccompanied by free hemorrhage elsewhere, simple decompression may suffice to relieve the pressure symptoms; for these are often largely due to the acute edema of the Cannon type, which occurs in the bruised nervous tissue.

Immediately fatal hemorrhages into the arachnoid spaces occur from the rupture of aneurysms of the superficial cerebral vessels (p. 218).

Occasionally large extravasations in the arachnoid spaces may become partially organized and leave thick-walled cysts, which may give symptoms resembling tumor. They are favorable cases for operation.

Intracerebral Hemorrhages.—Extravasations in the brain substance itself may be superficial and involve chiefly the cortex or subcortical layers; they may, on the other hand, lie deep in the centrum ovale or involve the basal ganglia and brain stem. The cerebellum likewise may be the seat of hemorrhage. The points from which bleeding has occurred may be single or multiple. The escape of blood may be due to the spontaneous rupture of a vessel involved in some process of disease or may be the consequence of trauma.

Etiology.—Those which occur as the result of vascular disease are usually single and ordinarily lead to a circumscribed clot of variable size. Possibly the most common source of such a hemorrhage (60 per cent. of all cases) is the rupture of a minute aneurysmal dilatation of a perforating vessel which arises from one of the basal arteries, especially from the middle cerebral. As pointed out by Charcot, one particular branch which passes from the base into the anterior part of the internal capsule and lenticular nucleus is particularly susceptible to such a lesion, and is the common source of the capsular extravasation in "apoplexy."

Next in frequency to these hemorrhages attributable to the arterial degeneration of middle and old age, occur the spontaneous bleedings associated with neoplasms. Certain varieties of gliosarcomata are extremely vascular, and whether due to an insufficient support given to new-formed vessels or to the undue dilatation through stasis of vessels which were originally present, hemorrhages are apt to occur within the substance of such tumors. Consequently symptoms of intracranial bleeding, which are often mistaken for apoplexy, in its common acceptation, may be the first indication of the presence of such a tumor. For this reason, when spontaneous intracranial hemorrhage occurs in young individuals in the absence of any marked evidence of arteriosclerosis, a diagnosis of "apoplexy" must be open to suspicion. Any unusual strain which is put upon the thin-walled vessels contained in a new growth, whether from exertion or passive congestion, may lead to vascular rupture and extravasation; and such an accident is particularly apt to follow any sudden alteration in intracranial tension, such as may follow the withdrawal of fluid by lumbar puncture or the protrusion of the brain through a decompression opening made directly over the tumor (Fig. 125, p. 231).

Cranial traumatism of any sort may lead to cortical hemorrhages in a variety of situations. We have seen that almost all severe cases of concussion are probably associated with minute lesions of this sort, which may be so small as to escape notice, or on section of the brain may be visible to the naked eye as punctate foci of extravasation. They may occur in any situation (Fig. 97). On the other hand, cranial injuries which have led to serious contusions or lacerations of the brain

may lead to irregular and widespread extravasations arising from the vascular cortical layer (Fig. 96).

Such complications, often promptly fatal, are the common result of gunshot wounds, although it is not unusual for a bullet to penetrate the skull and lodge in the brain without causing an extravasation extensive

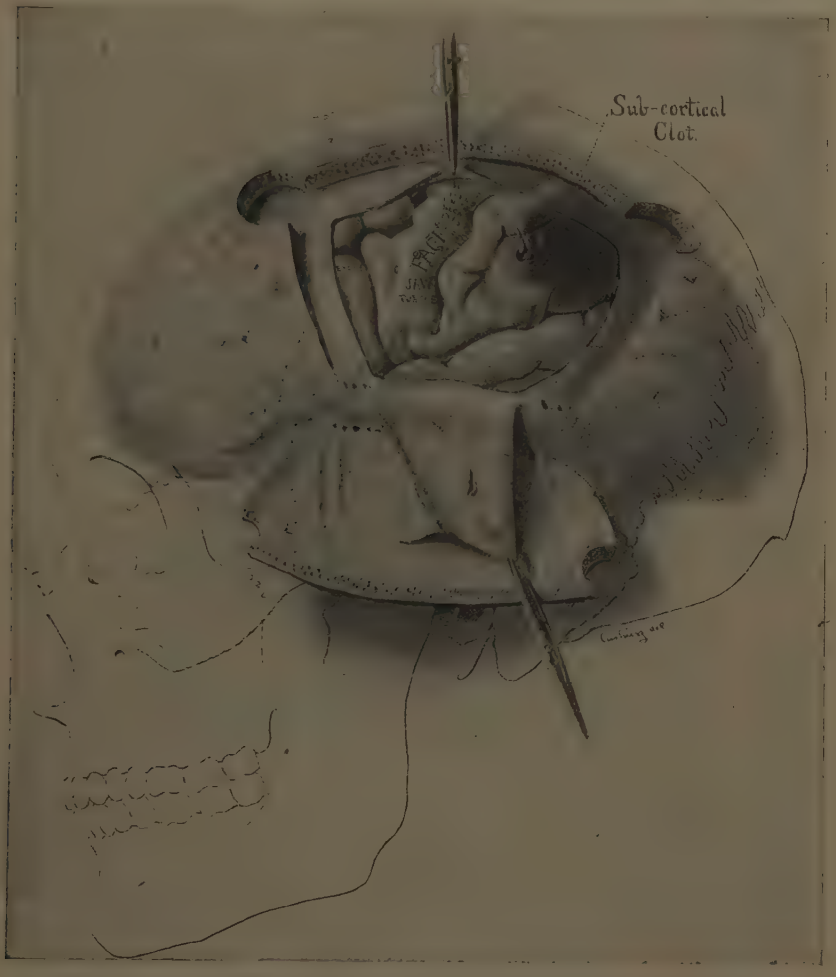

FIG. 112.—A CIRCUMSCRIBED SUBCORTICAL CLOT THE RESULT OF A STAB-WOUND. Symptoms were those of contralateral hemianesthesia and word-blindness. Sketch of operation. Note situation of central fissure in relation to clot and to excitomotor area. Complete recovery after evacuation of clot.

enough to lead to the paralysis stage of compression. A penetrating stab-wound may likewise fail to divide vessels of any importance in its course through scalp, skull, meninges, or cortex. It may, on the other hand, injure some subcortical vessel. Such a condition was found in a patient whose operative wound is represented in Fig. 112. Intracerebral hemorrhages of this sort may be the result of operative pro-

cedures themselves, especially when misdirected exploratory punctures with sharp-edged needles have wounded vessels in the depths of a fissure or in the brain substance itself.

Spontaneous cerebral hemorrhages may occur in certain cases some days after an injury to the head. This so-called "Spätapoplexie" (Bollinger) is supposedly due to foci of softening about a blood-vessel, which has ruptured from lack of tissue support.

Pathology.—A consideration of the morbid factors underlying spontaneous vascular lesions is possibly inappropriate in a surgical treatise. They hinge on conditions of endarteritis, periarteritis, aneurysmal formation, on areas of softening in the gray matter (Marie's lacunæ), and on the abnormal vascular conditions in some tumors. The surgeon is chiefly interested in the conditions which result from the extravasation when it has once occurred. Can they be benefited by an evacuation of the clot, in case its situation is recognizable and an operative approach to it possible? It is of chief moment to know whether the extravasated blood clots quickly or whether the continuance and advance of symptoms is due entirely, as in extradural hemorrhages, to a progressive increment to the clot from continued bleeding. It is my opinion that the extravasated blood does clot quickly and that one important reason for augmentation of pressure symptoms in the succeeding hours or days is edema of the surrounding cerebral tissue rather than continuance of hemorrhage. As a result of this edema and of pressure long continued, such neighboring nerve tracts as have escaped direct laceration from the hemorrhage may in the end be destroyed; and, furthermore, restoration of function of such adjoining tracts would be unlikely, owing to their probable ultimate implication in the cicatrix formed by Nature's slow method of organization of a large clot.

Small extravasations which have not implicated any important tracts are usually absorbed without leaving any discoverable trace of their presence, and are only serious when they occur in the neighborhood of vitally important centers. The larger extravasations are slowly absorbed and in time are replaced either by scar tissue or by cysts. In all probability the large porencephalic cysts which are found in many cases of infantile cerebral paralysis are attributable to extensive subcortical hemorrhages, the result of traumatism during parturition. The non-medullated infant's brain is probably much more easily disorganized by an extravasation than the adult brain, and consequently lesions of this particular type are a more common sequence of hemorrhages which have occurred in infancy. On the outer wall of such cysts one usually finds normally preserved pia and a thin layer of neurogliar tissue.

These questions, of early clotting and destruction of adjoining brain tissue as a secondary result of the presence of the clot, are of great importance in consideration of the possibility of relief from pressure which may follow an early approach to and evacuation of subcortical extravasations.

The *symptoms* are seen in their typical form in the sudden hemorrhage due to vascular disease, for here they are not obscured by the accompanying phenomena of concussion or other complications which arise in cases of traumatic origin. The striking feature is their sudden onset—the "stroke of apoplexy." Should the hemorrhage occur from a comparatively large arterial stem, one may observe, usually in the course of a few hours, the entire sequence of compression phenomena, which terminate in respiratory failure from permanent bulbar anemia. The rupture of such an extravasation into the lateral ventricle, with extension of the hemorrhage to the fourth, may lead to immediate death, though I am inclined to think that hemorrhage into the ventricles is less common than the text-books would indicate. In Fig. 113 is shown a section of the brain of a fatal case of apoplexy. A chronic ependymitis with ventricular hydrops was present, and yet the clot, which apparently

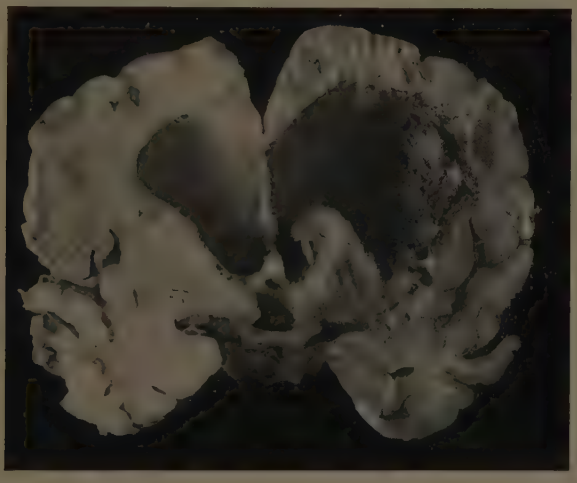

FIG. 113.—SECTION OF BRAIN OF FATAL CASE OF CAPSULAR APOPLEXY.
Although an old, chronic, acquired hydrops ventriculorum from ependymitis was present, clot did not break into cavity of ventricle, but remained covered by intact ependymal layer.

filled the ventricle, actually did not break into it, but remained covered by the intact ependymal layer.

With a less large and less tense extravasation, possibly from rupture of a smaller vessel or of a vein, the brain may make room for the clot and the circulatory disturbances due to its presence may be compensated in any one of Kocher's early stages.

In practically all cases of apoplexy, localizing symptoms are present and serve to show the side of the brain involved, even if they do not suffice clearly to indicate the exact size and situation of the clot. Even in the larger extravasations, when the patient is comatose and bulbar symptoms are present, the position of the eyes, the greater flaccidity of the limbs on one side and the disparity of the deep reflexes on the two sides serve to indicate which hemisphere is affected. In smaller extravasations the general compression symptoms are often subordinate

to the local ones; and although a slow pulse, a rise in blood-pressure, a low grade of choked disk, somnolence, etc., may be present, the more or less circumscribed paralyses (of motion, of sensation, of vision, of the speech mechanism and the like) prove to be the most striking feature.

In cases of spontaneous hemorrhage into tumors compression symptoms alone may be present without there being any evidence of the situation of the process. This is particularly apt to be the case when the tumor has been unsuspected, possibly no other symptom than a vague headache having preceded the "stroke." This means nothing more than that the tumor occupies a "silent" area of the brain, and a sudden increase in its size from the extravasation need not necessarily produce localizing symptoms. Should it have occasioned irritative or paralytic symptoms beforehand it would probably have been recognized before the hemorrhage occurred.

The *diagnosis* of intracerebral hemorrhage in traumatic cases can be less definitely made from the symptoms alone, for in these conditions hemorrhage of meningeal origin may exactly simulate the general evidences of compression, as well as the focal symptoms of paralysis seen when bleeding occurs in the substance of the brain. Furthermore, such hemorrhages are masked by the symptoms of contusion or laceration of the brain which lead to capillary effusion and edema, even in the absence of a subcortical clot.

Prognosis and Course.—The immediate outcome of intracerebral hemorrhage depends upon the rapidity of its formation, the amount of extravasation, and its tension. In the large apoplectic hemorrhages, unless some relief from pressure be afforded, death must ensue from bulbar paralysis in the course of hours or days. Patients may even reach Kocher's third stage of compression, exhibiting the phenomena of rhythmicity in blood-pressure and respiration and yet recover, although when this stage has appeared the condition must be regarded as critical. Further, when a period of Cheyne-Stokes respiration has been present, even should there be a subsidence of pressure phenomena, so that immediate risks are tided over, death may subsequently ensue from pulmonary complications due to inhalation pneumonia.

In case of recovery from the immediate pressure symptoms of apoplexy, the patient remains permanently afflicted with spastic paralyses of greater or less extent, perhaps aphasic or hemianopic; and particularly in the left-sided hemorrhages some degreee of mental deficiency is almost inevitable.

Treatment.—In the traumatic cases this differs in no way from that considered under other forms of intracranial bleeding. The extravasations due to surface lacerations are often cortical or immediately subcortical, and when the area has been exposed clots may be removed and pressure symptoms promptly abate. When the hemorrhage has occurred into a tumor, palliation of symptoms is the chief indication, and decompression by removal of the subtemporal shell of bone appears to be one of the best methods of giving temporary relief.

There remain for consideration the cases of apoplexy, in the presence of which we stand therapeutically helpless. The main reliance has been in venesection—a symptomatic form of treatment directed toward reduction of blood-pressure under the misconception that it is the high-pressure pulse which has led to the hemorrhage; whereas actually it is the hemorrhage which has led to the high-pressure pulse. If experimental observations are not at fault this is Nature's only way of continuing the necessary supply of blood to the bulbar centers which have become anemic in consequence of the pressure exerted against them. In cases in which the regulatory mechanism of the vasomotor center, which brings about the rise in blood-pressure, has not been strained to its greatest limit—in other words, when some reserve remains—bleeding may not be perceptibly harmful and the resultant lowering of blood-pressure may possibly serve to check the hemorrhage. However, after such bleeding the blood-pressure will always return to its former level unless the vasomotor mechanism fails. If it does not so return and the intracranial pressure remains consequently higher than the blood-pressure, which has been lowered by bleeding, a condition of bulbar anemia results. I have several times seen patients with apoplexy bled in the hope of benefit, and have been able to follow the blood-pressure in some of them. Invariably the symptomatic condition has been made worse unless there is sufficient vasoconstrictor reserve to again force the pressure to its former level. In the long run bleeding in these cases is unphysiologic and hazardous. I am, furthermore, inclined to the opinion that in most of these cases the intracerebral bleeding does not long continue, and consequently the hope of checking the symptoms by blood-letting is based on a wrong conception as to what is taking place in the brain.

Is it possible that by surgical measures a capsular clot—taking this as the typical form—may be evacuated? Would there be a fatal continuance of bleeding after such an evacuation? Can immediate degrees of fatal compression be thus warded off? Is the life of a patient, with a serious capsular hemorrhage, worth prolonging, in view of his future mental and physical incapacities? These and many other questions naturally arise.

The last question may be dismissed with a word. Did we know of any possible medicinal measures which could prolong life under these circumstances, no matter how undesirable it might be, we would not be justified in refraining from their employment, and why should surgical measures be looked upon as a thing apart from other forms of therapy? Certainly cases of right-sided apoplexy can be recovered from with inconsiderable disturbance to the patient's normal mental activity, even with the persistence of hemiplegia, and it is probable that the removal of a clot in the more seriously incapacitating hemorrhages of the left hemisphere would serve to lessen the posthemiplegic symptoms with which we are so sadly familiar. I have had one striking illustration of the prompt benefit from removal of a subcortical clot. The symptoms which it produced—namely, hemianesthesia, aphasia, word-blindness, etc.—cleared up within a few days after its evacuation, showing beyond doubt that they were in large part produced by pressure and few of them by actual destruction of nerve tracts. It is quite possible that the same thing may be true in

the cases of spontaneous hemorrhages from vascular disease. Doubtless in the same way, if a capsular clot should be evacuated and the cavity allowed to collapse, we would find that most of the serious paralytic symptoms are due to pressure rather than to actual laceration of the fibers which seem to have been implicated.

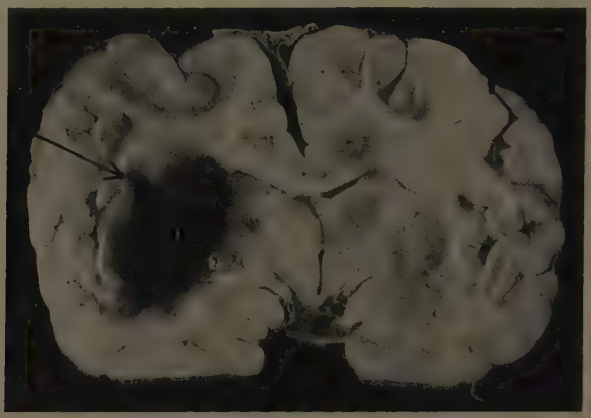

FIG. 114.—SHOWING POINT OF ELECTION FOR TAPPING USUAL CAPSULAR CLOT THROUGH THE POSTCENTRAL GYRUS ABOVE THE INSULA.
One of author's drained cases in which death was due to pneumonia and at autopsy cavity was found empty.

In regard to the continuance of bleeding, it may be said that in the majority of these cases rapid clotting is probable with little accession to the clot after the first few hours; and even if bleeding should continue it would be preferable for it to escape

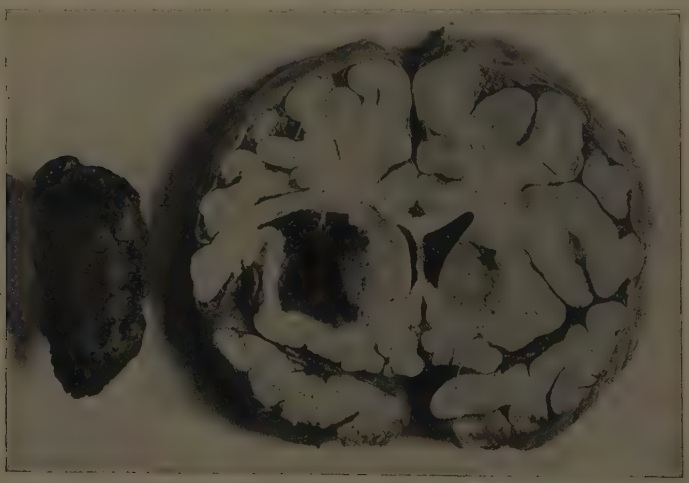

FIG. 115.—SECTION OF BRAIN OF AN EPILEPTIC WHO DIED FROM EFFECTS OF CAPSULAR HEMORRHAGE; WITH CLOT WHICH EXTRUDED ITSELF AT TIME OF AUTOPSY (see Fig. 49).

externally through an operative pathway than for it to continue to add to the damage already done by further destruction of the brain at its original seat.

Can such a clot be approached and can it be evacuated if it is disclosed? The usual situation of the extravasations is well known; also the fact that they often attain a considerable size; and it would be an easy matter from almost any point

of the cortex to tap such an extravasation as is usually disclosed at autopsy. It was my experience also with the three cases on which I have operated to find that as soon as the clot was located and the overlying cortex incised, it extruded itself rapidly, from the very fact of the intracranial pressure which it had produced (Fig. 114). Such a spontaneous extrusion may even take place after death, an illustration of which is given in Fig. 115. In this patient a depressed fracture of the skull had been received years before. The fragments were not elevated; he subsequently suffered from epilepsy, and in one of his epileptic attacks, forty years after the original injury, there occurred an intracranial capsular hemorrhage, in consequence of which he died. When the calvarium was removed at autopsy the old depressed fragments tore a small opening in the cortex, through which the clot immediately extruded itself.

One great difficulty which is encountered at such an operation is the extreme degree of tension of the brain, in consequence of which, on opening the dura, the leptomeninges can hardly escape from rupturing as the brain bulges through the dural opening. Special precautions, therefore, must be taken, lest a large hernia or fungus cerebri results. Here again a subtemporal approach is a wise one. In the earlier cases which I have operated upon the mistake was made of turning down a bone flap, and although in all of them pressure symptoms were immediately relieved, it was impossible to properly replace the bone flap, and difficulties from the local wound would have been encountered had the patients not died from pulmonary complications. I have since had a successful case by the subtemporal route.

It will doubtless be some time and require much experience before final rules for this procedure can be formulated. A generous removal of the subtemporal bone, by an approach through a split muscle, should be made before the dural opening is attempted. Then a small incision should be made in the upper part of the exposed area, corresponding with the lower end of the central convolutions; a blunt aspirator, or what would answer as well, a grooved director, should then be introduced directly toward the internal capsule through the summit of one of the exposed convolutions far enough above the Sylvian fissure to escape the insula (Fig. 114). Should this strike the clot, as it is almost certain to do, the puncture wound should be enlarged by the passage of a blunt instrument, also inserted through the comparatively bloodless center of the convolution, directly down to the clot. Through such an opening the clot will extrude itself, and for a few hours or days drainage from the cavity with a soft tube should be left between the edges of the divided muscle, the wound in the scalp and other structures being closed around it.

In conclusion, it may be said that intracerebral hemorrhages—capsular apoplexy being taken as their typical form—are not necessarily unsuitable for surgical measures; that by a proper and guarded approach which avoids the insula and which is conducted directly through one of the convolutions, such a clot may be safely tapped, its cavity opened, and the clot will then extrude itself; that the immediate danger of fatal compression may thus be warded off; and finally, that such a removal

of a clot will, in all probability, greatly lessen the residual paralyses, which doubtless are largely due to a slow pressure atrophy of adjoining tracts rather than to their actual destruction by laceration.

Thrombosis and Embolism.—Though hardly to be considered conditions which are amenable to surgical measures, there are certain consequences of a blocking of the cerebral vessels which may call for operative relief. An embolus which lodges in one of the vessels and shuts off the circulation from a given territory of the brain leads to an area of softening, the extent of which depends upon the particular vessel affected; the brain becomes diffluent and, what is of more importance, increases in size through swelling. This process may lead to an increase of tension sufficient to produce serious headaches, vomiting, choked disk, and even major symptoms of compression.

In consequence of this a differential diagnosis between the pressure from an area of softening and the pressure from actual extravasation of blood may be impossible. The symptoms may even simulate those of tumor, and in a recent case in Dr. Barker's clinic they were of such a nature as to lead us to attempt a decompressive operation, which disclosed a bulging diffluent brain with occlusion of the exposed middle cerebral artery.

It is important, for the recognition of these cases, not only to make a diligent search for a possible source of an embolus, but to have as definite a knowledge as possible of the anatomy of the cerebral vessels and of the symptomatology of the lesions which follow their pathological closure. A patient with an extensive mitral lesion recently seen with T. B. Futcher, presented symptoms closely simulating those of a cerebral abscess following an otitis media, with fever, headache, vomiting, leukocytosis, mastoid and suboccipital tenderness, etc. Examination had shown the presence of a crossed anesthesia, together with the ocular and laryngeal symptoms which characterize thrombosis of the posterior inferior cerebellar artery.

The presence of chronic endocarditis must always lead to the suspicion that the cerebral lesion is due to embolism, but it must be borne in mind that when this lesion leads to pressure symptoms, relief from pressure by decompression may be called for just as in cases of edema following trauma.

There is another form of embolism, seen occasionally in surgical wards—namely, that due to circulating particles of fat which have reached the blood-stream from the bone-marrow after fractures. There is no known method of treatment.

Aneurysm.—The miliary aneurysm, so frequently a demonstrable cause of apoplexy, need not be considered. Aneurysms of the larger vessels, particularly those of the base, the internal carotid, basilar and middle cerebral, are not exceptionally rare. They may result from injury to a vessel even with no evidence of general arterial disease; they may follow the lodgment of an embolus, owing to the resultant change in the arterial wall. They may reach a considerable size (Fig. 116)

without symptoms, or, on the other hand, from pressure they may closely simulate a cerebral tumor. This is particularly true of aneurysms of the internal carotid, arising in the interpeduncular space near the optic chiasm; for they lead to hemianopsia, optic atrophy, or oculomotor palsies, in addition to the severe headaches which they may occasion and which closely simulate those due to pituitary tumors.

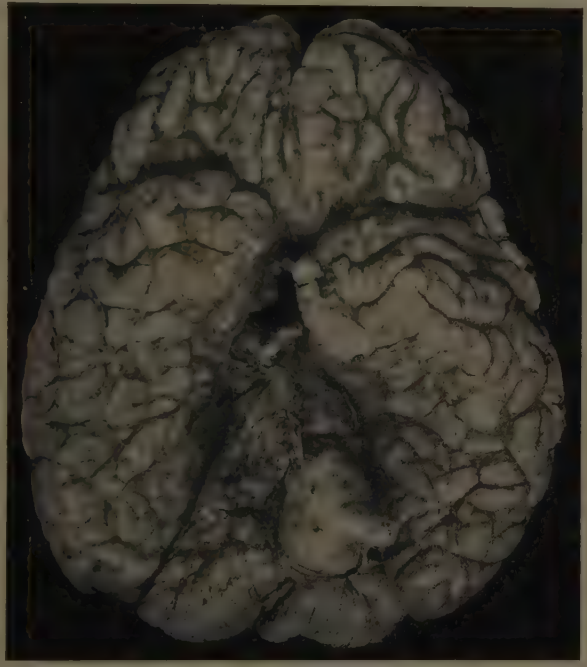

FIG. 116.—ANEURYSM OF BASILAR ARTERY.
Sudden death from rupture. No previous symptoms. (Kindness of Allan Starr.)

They may occasionally be recognizable by a murmur, but this is less characteristic of the simple saccular variety than of the arteriovenous form of intracranial aneurysms. They are rarely diagnosed and usually terminate in rupture with sudden death. It is possible, in case a diagnosis is made or in case an aneurysm is disclosed during an operation for a supposed tumor, that they could be successfully treated by wiring.

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CEREBRAL TUMORS.

Varieties.—Owing to an uncertain terminology it is difficult to give exact figures of the occurrence, character, and operability of different varieties of brain tumor, even were statistics in other respects of great value. From the careful tabulations and notes made by Oppenheim, Knapp, Starr, and many others, certain conclusions may be drawn. Almost every known variety of tumor has been found in the brain. All told, the infectious granulomata are by far the most commonly recorded type.

Tuberculomata are occasionally primary,—at least careful post-mortem examinations have failed to disclose, in certain cases, any

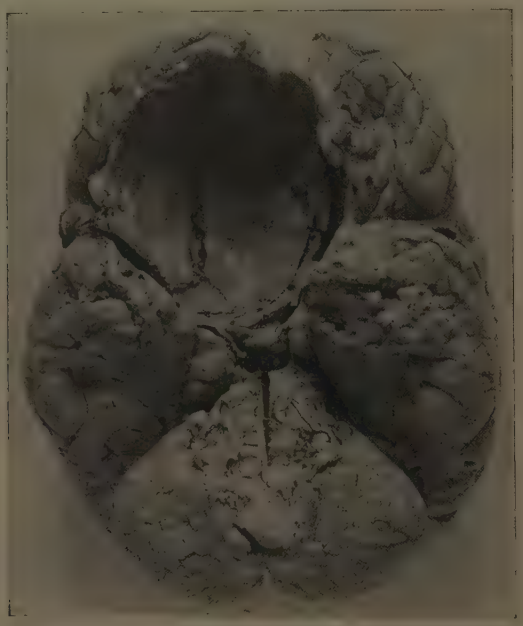


FIG. 117.—SHOWING CAVITY LEFT AFTER REMOVAL OF ENCAPSULATED MENINGEAL ENDOTHELIOMA. From brain of patient dying in the Government Hospital for the Insane. (Kindness of I. W. Blackburn.)

other focus of disease. They are usually multiple and vary greatly in size; they may acquire a thick capsule, and in this case are favorable for operative removal; they may lead to tuberculous meningitis. Their most frequent seat is in the cerebellum and they occur with especial frequency in children. **Syphiloma** represents the form of infectious granuloma common in adults. Unlike the gummatous meningitis already described, it represents a form of growth which is very resistant to antiluetic measures. These dense, fibrous gummata are usually superficially placed, and thus are often accessible to the surgeon. They may reach a large size and are often multiple. (See Meningeal Syphilis, p. 144.)

Endothelioma.—These tumors, often classified as fibrosarcomata, are known to be the most frequent form of true neoplasm. They arise usually from the meninges, are encapsulated, loosely attached, and do not form metastases. They affect the nervous tissue by pressure (Fig. 117) rather than by infiltration, and hence disturbances of function are apt to subside after their successful surgical removal. They are often accessible, and as they can be shelled out, offer the most favorable type of tumor for operation. They are of the same histological character and gross appearance as the tumors which frequently occur in the spinal meninges. A favorite seat for these growths is in the cerebellopontine recess (Fig. 123).

Glioma.—These primary tumors arise from the neurogliar connective tissue. They are soft, often possessing little more consistency than the brain itself, infiltrating, and their exact limits are often difficult to determine even on microscopical examination. They may reach an enormous size. They often undergo degeneration and become more or less cystic. They are usually vascular and hemorrhages occur in them (Fig. 125), so that a supposed stroke of apoplexy may be the first indication of their presence. There are several subvarieties of uncertain classification.

There are certain mixed tumors—*gliosarcomata*—which partake of the histology of both of the above forms.

Cystic tumors are not uncommon (Fig. 118). They are usually of parasitic (echinococcal or hydatid) origin or are the result of traumatic injuries. They progressively increase in size and lead to pressure symptoms, and in this respect differ from porencephalic cysts which are probably a sequel of hemorrhage, and which may cause irritative and paralytic symptoms, but not those of pressure. Cysts may occur in any part of the brain. Oppenheim has called attention recently to those occurring in the fourth ventricle. Cysts may be left by the degeneration of a glioma.

Carcinoma, particularly of metastatic origin, is not uncommonly seen. Metastases usually lodge primarily in the bones and secondarily invade the cranial chamber. The same is true of many forms of sarcoma of the skull, which arise there primarily or are the result of metastasis. Other varieties of tumor are less common. Forms of *fibroma*, *angioma*, *myxoma*, *psammoma*, *osteoma*, *cholesteatoma*, *lipoma*, and *teratoma* have been described.

Little is known of the etiology of these forms of tumor, which are not due to infection or metastasis. It is noteworthy, however, that a great number of them date back to the reception of a more or less serious cranial injury. Their situation is variable; no part of the brain appearing to be exempt although certain forms are more common in certain situations. Thus, tuberculoma is most common in the cerebellum, syphiloma in the basal meninges, endothelioma in the meninges of the subtentorial region, cysts in the cortex, cholesteatoma in the temporal lobe, teratoma in the pituitary body and mid-basal region, etc.

The brain may be greatly displaced by tumors. It is usual to see, in brains hardened *in situ* by carotid injections before removal, that the lips of the cerebellum and the medulla are crowded down into the foramen magnum. This displacement is most pronounced in cerebellar growths, and it probably accounts for the sudden death, after lumbar puncture, in cases of tumor (Fig. 118). Marked dislocation of

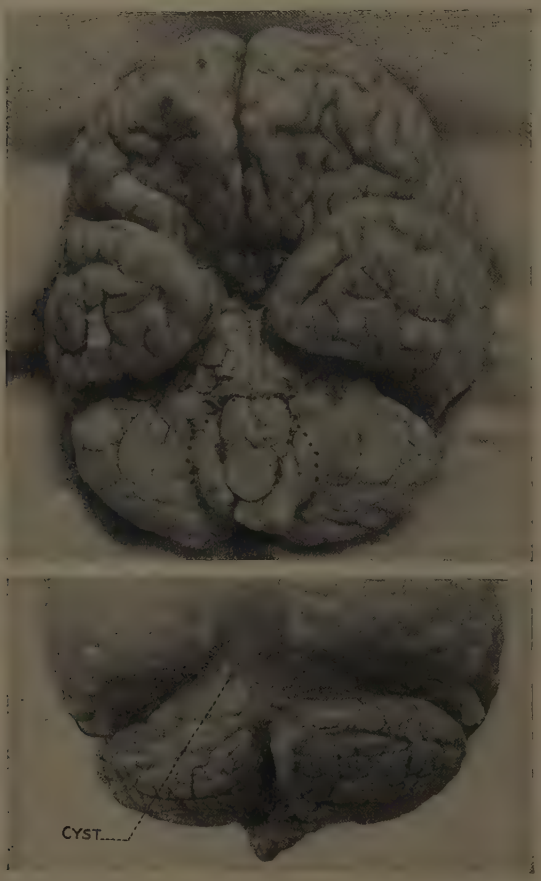


FIG. 118.—BRAIN OF ADULT WHO DIED SUDDENLY AFTER WITHDRAWAL OF FLUID BY LUMBAR PUNCTURE.

Note cyst of left cerebellar lobe; also hernial mould of medulla and cerebellum crowded into foramen magnum, the imprint of the margin of which is shown by dotted lines.

the falx, as well as of the nervous structures, may occur in cerebral growths (Fig. 125).

Symptoms.—These are usually divided into: (1) *General or underlying symptoms*, due to the progressive increase of intracranial tension, and (2) *special* or *localizing symptoms*, which depend upon the part of the brain involved.

(1) The *general symptoms* of brain tumor are (1) headache, (2)

nausea and vomiting, and (3) choked disk; and vertigo and convulsions are added to this triad by many clinicians. It is to be noted that pressure symptoms which characterize acute lesions (namely, rise in blood-pressure, slow, vagus pulse and Cheyne-Stokes respiration) are conspicuous by their absence.

These three cardinal symptoms are pressure phenomena merely, and, irrespective of the nature, size, or situation of the growth, they may be present in the total absence of localizing signs. Thus, a growth of any kind may reach a considerable size and yet lie in a silent area of the brain, involving association paths alone and blocking encephalic processes too obscure for our detection. Again, a small tumor no larger than a pea can obstruct the iter and lead to an internal hydrocephalus, producing general symptoms but no localizing signs whatever. Thus it is that subtentorial tumors may lead, early in their course, to severe pressure symptoms, whereas in tumors of the frontal regions they may be long delayed.

Headache is usually of a diffuse, dull character, and in early cases may occur only at certain times of the day, most often in the morning hours. It may be frontal, occipital, or on one side; but its situation is rarely of any localizing value, unless it happens to be constantly referred to one spot, which proves tender to pressure or percussion. This feature may indicate an underlying growth which has arisen in the membrane and is pressing against the skull. Headache is probably due to pressure or dislocation of the dura or of its expansions (the falx, and tentorium) for, of the cranial content, this membrane alone is sensitized.[1] Intracranial pain of some form or other and at some stage of the disease is rarely absent; it may be insufferable.

Vomiting may be absent or only appear at rare intervals, and it may or may not be attended with nausea. It often occurs irrespective of food; it is often projectile; it often occurs only in the early morning hours. I have seen cases in which the head could not be raised from a recumbent posture without immediate vomiting, though other symptoms were entirely latent. This condition continued for weeks in one patient from whom a frontal lobe tumor had been successfully removed. Whether vomiting is due to irritation of a separate center in the medulla, whether from stimulation of the vagus center itself, or whether associated with the dizziness and due to auditory nerve disturbances from stasis, is not clear. When present it leads to rapid loss of weight and strength.

Choked disk is one of the most reliable signs of tumor, though it must be remembered that the cerebral edema in cases of Bright's disease may lead to changes in the retina—the so-called albuminuric retinitis—which are, for the most part, indistinguishable from it. In reality I believe the process to be the same (p. 161). The swelling may vary from a slight blurring of the edges of the disk, with tortuosity of the veins, to an intense swelling of the nerve head of seven diopters, accompanied with hemorrhages. The edema likewise often spreads out over the retina. It must be kept in mind that a high grade of choked disk is not incompatible with well preserved vision, as Hughlings Jackson first pointed out. Vision does not fail until the nerve begins to undergo atrophy. The two eyes are not always equally involved, though this does not offer much help in localization. An involvement of one eye alone, however, may be taken as a probable indication that the growth implicates the

[1] The dura, however, is only sensitive to a pull or pressure, not to an incision, suturing, etc.

corresponding side of the brain and is not far removed from the back of the orbit. The choking from tumors which are remote—subtentorial ones, for example—is bilaterally equal.

In cases of tumor one or more of these three cardinal symptoms may be absent at any given time, and through the entire course of the disease it is possible that all three of them may never have appeared. There are cases in which vomiting is the only symptom; others with headache alone; still others in which failing vision has led to the accidental discovery of a choked disk. Some degree of headache, however, is usual and may figure as the only symptom until late in the disease.

Certain tumors may reach a large size and give practically no indication whatsoever of their presence. This can occur with the soft, infiltrating gliomata, which destroy brain substance as they progress (the same may be true of an abscess), and hence lead to no general

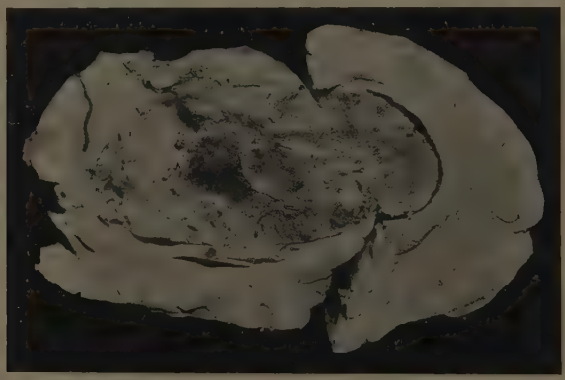


FIG. 119.—LARGE GLIOMA OF LEFT PREFRONTAL LOBE COMPRESSING AND DEFORMING RIGHT FRONTAL LOBE WITHOUT INVASION.
Mental symptoms observed for only two weeks preceding death.

pressure symptoms, and, when in a "silent" area, to no local ones. Thus an autopsy may reveal an entirely unsuspected tumor, particularly in cases of frontal-lobe involvement, for the slow alterations in mentality may have passed unnoticed even if they were present. In one of my cases general pressure symptoms with change in disposition, etc., had been observed for only two weeks, and yet at operation a large irremovable glioma was found (Fig. 119), involving both frontal lobes. A further detailed review of the history then brought out the fact that for a year he had been somewhat irritable and had shown less interest in and less aptitude for his work—symptoms which had passed unnoticed by most of his relatives and intimates.

(2) *Localizing symptoms* indicating the site of the tumor may or may not be present, according to whether the portion of the brain involved by the pressure or destruction of the growth gives symptoms which, in the present state of our knowledge of cerebral function, are

recognizable by our crude methods of examination. It may here be emphasized that cases of brain tumor may present localizing symptoms alone, with no general pressure symptoms; just as the reverse may occur. Thus, an infiltrating glioma may originate in some area, irritation or paralysis of which gives symptoms which clearly indicate the part of the brain involved, and yet no pressure symptoms may have appeared. It is for this reason that signs of focal irritation—Jacksonian epilepsy, for example—or focal palsies should lead to early exploration, provided the seat of trouble is surgically approachable, in the hope that a small and removable growth may be the offending agent.

Briefly, in consideration of what has already been said of the function of different cerebral areas (p. 155), some of the more important localizing symptoms of tumor are as follows:

Tumors of the *precentral gyrus*. A growth in or near this electrically excitable strip of cortex usually leads first to epileptiform fits of a focal and spreading (Jacksonian) character; later to paralysis, which is progressive in the same groups of muscles. There is an increase of deep reflexes due to degeneration of the pyramidal tract.

Tumors situated in the *postcentral convolutions* are apt to lead to fits of this same character, but they are commonly preceded by a sensory aura. Recognizable sensory disturbances for the modalities of pain, temperature, and, more rarely, touch may appear during the further advancement of the growth.

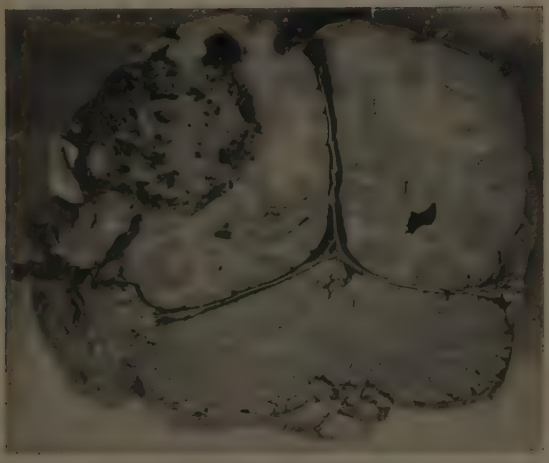


FIG. 120.—GLIOMA OF LEFT PARIETAL LOBE, WITH MULTIPLE HEMORRHAGES.
General symptoms relieved by decompression for many months. Local symptoms were hemianesthesia, hemianopsia and visual word-blindness.

Tumors in the *parietal lobe* may also lead to Jacksonian attacks preceded by sensory symptoms. A degree of aphasia is apt to be present when the left angular gyrus is involved, with especial loss of understanding of written words and letters (word-blindness). On the advance of these tumors there may be some permanent disturbance with sensation of the cortical type (involvement of extremities more than trunk) on the contralateral side of the body; also disturbances with muscle sense, posture sense, or sense of position in space; also inability to recognize the form or consistency and to name objects placed in the affected hand—asterognosis.

It is to be remembered that a considerable shutting off of afferent impulses, namely, sensation, necessarily affects the execution of normal movements, so that conditions simulating involvement of the pyramidal tract accompany an extensive lesion of this area. Growths in this situation when deeply placed oftentimes compress the optic radiation, leading to hemianopsia (Fig. 120).

Tumors of the *frontal lobe* may be difficult to localize, for slight disturbances in mentality may long pass unnoticed (Fig. 117). Mental attributes are altered, particularly when the lesion occupies the left frontal lobe and its prefontal area. Mental torpor, loss of memory, irritability, change of habits, etc. (Fig. 119), may go on to actual imbecility. It is not uncommon to find frontal-lobe tumors at autopsy among those who have been confined in asylums. In their backward extension, motor aphasia or irritative symptoms from implication of the precentral motor strip may occur. Cases have been recorded of tumors in the so-called writing center at the base of the second frontal convolution associated with pure agraphia.

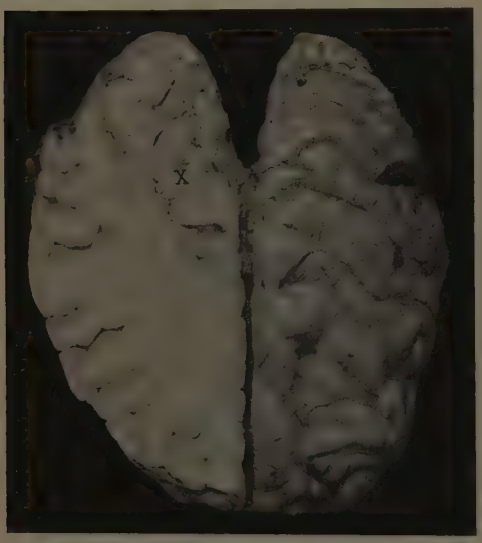


FIG. 121.—INACCESSIBLE SOLITARY TUBERCLE (AT *X*) OF THE CALCARINE REGION, GIVING SYMPTOMS OF TUMOR WITH HEMIANOPSIA.

Tumors involving one *occipital lobe* or the optic radiation (Fig. 121) cause hemianopsia; of both lobes, blindness. Occasionally color vision may be affected alone.

Tumors of the *temporal lobe* may attain a large size without marked symptoms, unless they involve the lower motor centers. On the left side, however, when the superior temporal gyrus is involved, they may lead to pronounced aphasia due to word-deafness. When the apex of the temporal lobe has been invaded and the uncinate gyrus affected, there are disturbances of taste and smell, and cortical convulsions may occur, preceded by a gustatory or olfactory aura. Peculiar attacks of a dreamy or "reminiscent" state have been described as characteristic of tumors in this situation.

Tumors of the *mesial surface* and of the *corpus callosum* are rare and give no distinctly characteristic symptoms. Disturbances of intelligence are common in the latter and thus they resemble frontal-lobe lesions.

Tumors of the *basal ganglia* lead to pressure on the internal capsule and thus involve the chief motor and sensory pathways to the cortex, leading to hemiplegia, hemianesthesia, hemiataxia, or hemianopsia. Lesions of the thalamus are apt to cause athetoid movements or tremor of the opposite limbs. The deep reflexes may be increased; the superficial absent,—Babinski's toe phenomenon in particular. Muscular sense and stereognosis are usually affected. The complex function of the ganglia makes it difficult to ascribe definite symptoms to lesions there, and being inaccessible they are suitable for decompressive measures only.

Tumors of the *corpora quadrigemina* lead to a staggering gait, to a tendency to fall to one side and backward, to a failure of sight and hearing, to nystagmus and to palsies of the ocular movements without true paralysis of the oculomotor nerves.

Despite the early serious symptoms they produce, owing to obstructive hydrocephalus, these tumors may reach a large size (Fig. 122).

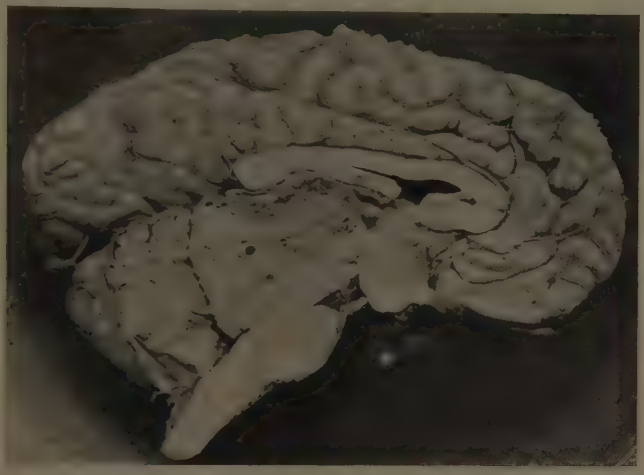


FIG. 122.—MID-LONGITUDINAL SECTION OF BRAIN TO SHOW LARGE GROWTH ORIGINATING IN THE CORPORA QUADRIGEMINA.
Note dilatation of third ventricle; also compression of cerebellum and dislocation of splenium of corpus callosum.

Tumors of the *crura cerebri*, of the pons, and elsewhere in the mid-brain, though localizable, like those of the corpora quadrigemina, are not accessible for operative removal and are usually unsuitable for simple decompression, for the reason that they are apt to lead to obstructive hydrocephalus—a condition which not only serves in time to mask the localizing symptoms, but also to prevent relief from the usual palliative measures.

Tumors of the *cerebellum* are frequent, often within easy surgical access, and, as a rule, easily localizable. They lead early to general symptoms owing to closure of the channel of exit for the cerebrospinal fluid. Hence, choked disk occurs in a larger proportion of cases and earlier than with tumors primarily involving the cerebral hemispheres.

FIG. 123.—MENINGEAL ENDOTHELIOMA OF RIGHT CEREBELLO-PONTINE RECESS, ELEVATED FROM ITS BED.
Note flattening of pons and excavation by pressure of lateral lobe of cerebellum.

As Stewart and Holmes have emphasized, we must distinguish symptoms due to intrinsic or intracerebellar tumors from those due to extracerebellar tumors. In *intracerebellar tumors*, in addition to the usual pressure symptoms, vertigo is commonly present, with the apparent movement of self or of surrounding objects.

Focal symptoms are shown by disturbances of the musculature on the same side of the body as the lesion: these are a staggering gait; a tendency to fall in a particular direction, often toward the side of the lesion; ataxia of a coarse variety and muscular flaccidity, both more marked in the limbs on the side of the lesion; nystagmus, particularly on looking toward this same side; a peculiar posture of the head, which may be tilted toward the lesion and rotated toward the opposite side. Fits of an unusual character may also be present. There is apt to be local tenderness on pressure over the suboccipital region, greater on the side of the lesion. Cerebral nerve symptoms are usually absent.

Extracerebellar tumors favorable for operative removal often lie in the *cerebello-pontine recess* and cerebral nerve symptoms are always present. These growths are

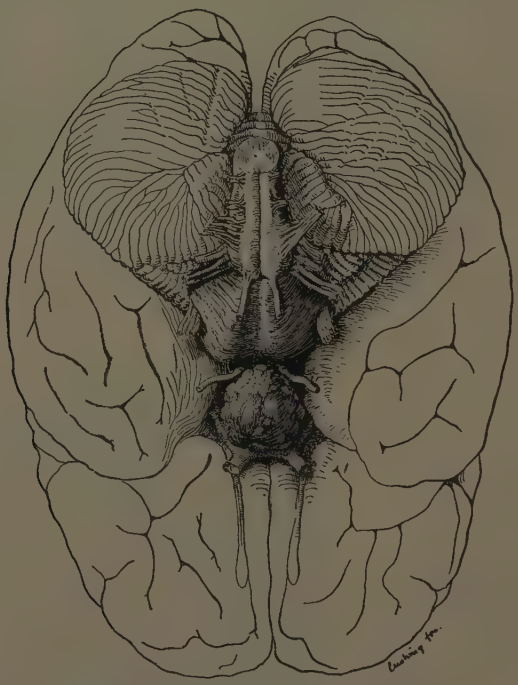


FIG. 124.—TERATOMA OF THE PITUITARY BODY WHICH CAUSED BITEMPORAL HEMIANOPSIA AND ARRESTED SEXUAL DEVELOPMENT.

supposed to arise from the acoustic nerve and tinnitus with unilateral deafness is often the first symptom. They enlarge slowly and it may be years before some pressure palsy of the facial, abducens, or trigeminal nerve occurs (Fig. 123). The growth in time compresses the lateral lobe of the cerebellum and pons, when local symptoms similar to those recounted above will put in an appearance. General symptoms also may ultimately appear from closure of the iter, though they may be delayed for years.

Pituitary body tumors (Fig. 124), from their proximity to the back of the optic chiasm, affect the fibers passing to the nasal half of each retina, leading to a bitemporal hemianopsia (cf. Fig. 88, p. 166). Symptoms of acromegaly may accompany them. There may be no choked disk, but primary atrophy of the nerves occurs from pressure. Severe headache is common; also vomiting. Amenorrhea and loss of

sexual power are present, as a rule. Sir Victor Horsley has successfully operated on a considerable number of these cases.

Tumors arising in the *bones*, and especially those *from the cranial base*, are common and often give characteristic symptoms. This is particularly true of growths which invade the middle fossa from the nasopharynx and sphenoidal cells, for they affect the trigeminus and oculomotor nerves early in their invasion of the cranial chamber. As they pick out the cerebral nerves in this way they are often mistaken for a luetic process.

In summation it may be said that although brain tumors may be present and give no symptoms, it is the rule for them, even when in silent areas, to give general symptoms of brain pressure, and when in other areas it is the rule for them to give symptoms which render many of them localizable. However, even to the most expert, there may arise signs which are most misleading, due oftentimes, as Collier has emphasized, to secondary disturbances, such as focal edema or other vascular changes which affect areas remote from the primary lesion.

Diagnosis.—There are three things to be considered: (1) The existence of a growth, (2) its situation, and (3) its variety. Though it is usually a matter of no difficulty to recognize the presence of a tumor when the general symptoms are outspoken it must be remembered that they may be wanting entirely, and if no focal symptoms are present, in other words, if the lesion affects a silent area, all signs may fail. This is a frequent experience with tumors of the frontal, the temporal, and the right parietal lobes.

When tumors are localizable we may infer something as regards their nature, since tumors of certain kinds have seats of predilection, as has been pointed out. The course of the disease, character of onset of symptoms, the age of the patient, and the presence of concomitant lesions also aid us in determining the variety of the lesion.

Tumors may be closely simulated by abscess, by gummatous meningitis, by ependymitis and acquired hydrocephalus, and, most important of all, by the cerebral symptoms of chronic nephritis.

Abscess most commonly follows otitis media or cranial injuries. Fever and leukocytosis, though not always present, are more probable than in tumor. The symptoms occur more acutely than in tumor, and though they may persist over a long period of months, they often show entirely quiescent intervals.

Gummatous meningitis and other forms of cerebral lues may give symptoms identical with tumor. A vigorous antiluetic treatment may clear up the diagnosis, even if involvement of the cranial nerves, the "ebb and flow" of symptoms, etc., are not sufficiently characteristic. It must always be remembered that the symptoms of a glioma often subside temporarily under iodids and mercury, and so the "therapeutic test" may be misleading.

Primary *ependymitis* with ventricular hydrops may closely resemble those cases of tumor which, early in their course and before there are localizing symptoms, lead to obstructive hydrocephalus. Both conditions result in bilateral spastic paralysis if the lesion is symmetrical. Occasionally there is a unilateral dilatation of one ventricle in ependymitis. A fluctuation of symptoms is more probable in ependymitis than in hydrocephalus from tumor. A cytological examination of the lumbar fluid may help.

Chronic nephritis is often characterized by headache, vomiting, and so-called "albuminuric retinitis;" in other words, by general symptoms of tumor without signs of a local lesion. In some of these cases the urine may show little change and yet the cerebral symptoms be marked; in many cases of tumor, on the other hand, albumin and renal elements may be present in the urine. Hence it is that diagnostic confusion may often arise. I have seen so many cases of "albuminuric retinitis" which prove to be the choked disk of tumor and vice versa, that I doubt whether there are any actual distinguishing features between the two processes. In nephritis the symptoms are doubtless due to cerebral edema, as Bramwell was one of the first to suggest, and they may be relieved by a decompressive operation or by a withdrawal of fluid from the lumbar region, just as may the symptoms of acute serous meningitis. Even in the presence of uremia with convulsions, possibly also due to pressure anemia, the acute symptoms may thus be warded off.

Lumbar puncture as a diagnostic or therapeutic measure, however, must be employed with great caution in these cases, for should the condition prove to be one of actual tumor, sudden death may follow the withdrawal of a considerable amount of fluid. Many fatalities from this source have been recorded. It is unfortunate that bacterial, cytological, or chemical examination of the fluid does not serve to differentiate between the two processes. Such examinations are helpful only in the presence of infective meningitis, whether it be of pyogenic, tuberculous, or syphilitic form.

Further, it must not be forgotten that the first symptoms of tumor may arise through cortical irritation or from sudden hemorrhage into the tumor; so that *Jacksonian epilepsy* and *apoplexy* are symptomatic diagnoses which are not uncommonly made without due regard for the process underlying them. "Apoplexy" in a young individual, without evidence of general arterial disease, must always be open to suspicion. Extreme *anemia*, *chronic lead-poisoning*, and *thrombosis* or *embolism* may at times simulate brain tumor.

A *radiograph* may occasionally prove of value, though on the whole it is most disappointing as a diagnostic aid. It is of particular value in the recognition of basilar tumors like those of the pituitary fossa, which have led to deformation of the sella turcica or absorption of bone.

Course and Prognosis.—There is such great variability in the nature, situation, rapidity of growth, and complications of cerebral tumors that no definite data can be given under this heading. A slow-growing endothelioma may be tucked away for years in the lateral recess and give few symptoms, until they suddenly unfold owing to obstructive hydrocephalus. I have removed one of these tumors from a patient who had had unilateral deafness for twelve years, but in whom general pressure symptoms had only been present for three weeks. On the other hand, with an infiltrating glioma symptoms may be present from the onset and their progression rapid. The course of any growth may suddenly be altered by hemorrhage (Fig. 125), by occlusion of vessels leading to areas of softening, by edema, and by hydrocephalus. When pressure symptoms occur, with headache, vomiting, and choked disk, prolongation of life for more than a few months need not be expected; when they are absent patients may live for years.

Occasionally, by natural processes, the pressure from the tumor may be relieved. This can occur in two ways: (1) In childhood, when the intracranial pressure may serve to separate the cranial bones and

lead to a marked enlargement of the head, and (2) either in childhood or adult life, when a superficially placed growth succeeds in causing a pressure atrophy of the overlying area of skull. Both of these processes accomplish what palliative operations accomplish—namely, a decompression; but, unlike the operative decompressions, they do not save the patient's vision, for a degree of pressure from within necessary to open the sutures or absorb the bone will almost certainly lead to an optic atrophy before this is accomplished. Tumors which have been thus decompressed may attain an enormous size (Figs. 126 and 127).

In still another way natural processes may serve to prolong or even to save life; namely, when tumors undergo degeneration. Sir Victor Horsley has commented on the occasional disappearance of brain tumors which have once been exposed at operation, and in the 100 cases of brain tumor which have come under my observation, I have seen 2, possibly 3, cases which seem to corroborate his astonishing statement.

FIG. 125.—LARGE GLIOMA PRIMARILY INVOLVING RIGHT CENTRAL CONVOLUTION AND CAUSING HEMIPLEGIA AND HEMIANESTHESIA.
Extensive hernia through large bone defect made directly over tumor. Death some months later from hemorrhage. Clot shown at *X*.

Allan Starr has had a similar experience with long periods of latency in certain cases of tumor. This usually is due to the cystic degeneration of a glioma.

The average duration of life in cases of brain tumor is said to be three years. We have seen, however, that under certain circumstances they may last for a normal lifetime; on the other hand, that they may lead, without warning, to sudden death from medullary involvement, after hemorrhage, lumbar puncture, edema, etc. Hence the prognosis is most uncertain. In the great majority of cases ultimate cure is not to be expected. There are few cases, however, which cannot be symptomatically benefited and in whom life cannot, at the same time, be prolonged by medicinal or, better, by surgical measures.

Treatment.—Aside from such simple measures as serve to palliate the severity of given symptoms (the coal-tar products for headache, with morphin as a last resort; bromid preparations for convulsions, etc.), we have long stood helpless in the presence of a brain tumor.

Our chief therapeutic reliance is placed on antiluetic measures, in the often vain hope that syphilis may be at the bottom of the trouble. It is, therefore, the custom, and usually, though not always, a proper

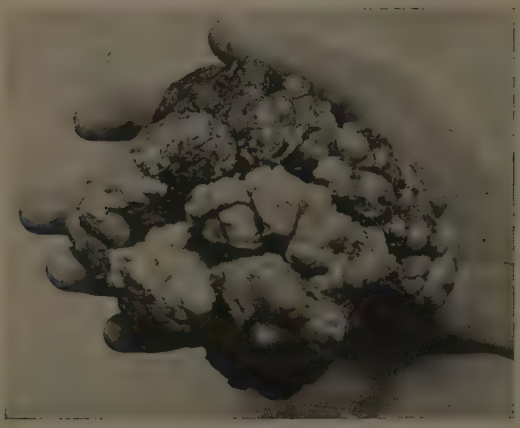


FIG. 126.—NODULAR GLIOSARCOMA WEIGHING 396 GM. REMOVED FROM BRAIN SHOWN IN FIG. 127, WITH FATAL RESULT.
One of the largest recorded tumors.

one, to institute a vigorous course of this so-called specific treatment. There are certain cautions to be observed for (1) certain forms of gummatous tumors may be very resistant to the iodids and mercury,

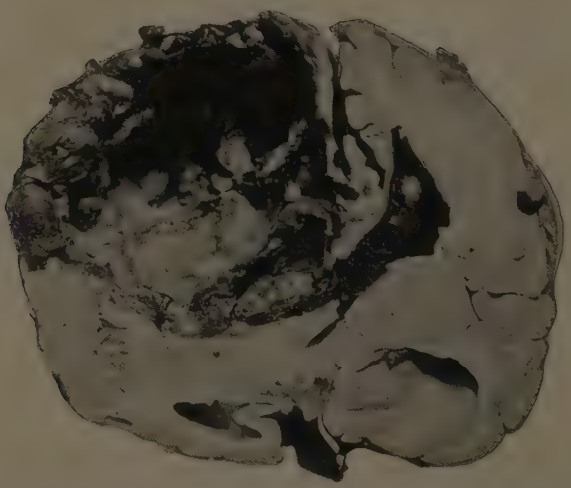


FIG. 127.—CAVITY LEFT AFTER EXTIRPATION OF ENORMOUS ENCAPSULATED NODULAR GLIOSARCOMA (FIG. 126) OCCUPYING ALMOST THE ENTIRE RIGHT HEMISPHERE.
Note obstructive hydrocephalus and clot in left ventricle, possibly the cause of operative death.

and during a prolonged course of treatment a choked disk not uncommonly is seen to go on to atrophy; and (2) certain cases of true neoplasm may show temporary and marked amelioration under this form of

therapy, and a time favorable for surgical removal of a growth may be passed by, owing to a diagnostic misinterpretation of the therapeutic improvement. It may be noted further that the active iodid therapy may greatly upset the digestive functions and perhaps may lead to nutritional disturbances in addition to those which the pressure-vomiting may itself occasion.

It may be said that when there is an urgency of symptoms, particularly with an advancing choked disk, operative measures must be resorted to at once and the drug treatment resumed only after the immediate pressure symptoms have been relieved. If, on the other hand, the symptoms are not urgent, a vigorous medicinal treatment may first be tried. Horsley, in 1890, endeavored to get clinicians to agree upon a definite probationary period of drug treatment for these moderate cases. He then suggested six or eight weeks as the limit of time, after which, if cure has not resulted, the advisability of surgical measures must be contemplated. Starr, in 1893, placed the limit of time at three months—a period which he doubtless would modify to-day, in view of the great technical advances made in our methods of relieving pressure in these cases. It must be emphasized that improvement in subjective symptoms alone is not a sufficient justification for the prolonged continuance of the specific treatment; the matter must hinge entirely on whether there is at the same time a subsidence in the choked disk. Hence, frequent examinations of the fundus, with measurement of the degree of swelling, frequent tests of the acuity of vision, and records of the visual fields are absolutely necessary. Judgment in these matters needs special training, not possessed even by many ophthalmologists. Using the condition of the eye-grounds as the main criterion, it may be found unwise to prolong medicinal treatment even as long as Horsley has suggested.

If in any case surgical measures may seem advisable, there are two ends we may have in view; one of them merely to alleviate the symptoms, the other to cure by removal of the growth.

Palliative operations are appropriate to those cases of inaccessible or accessible and non-removable growths, in which headache is insufferable or in which there is threatened blindness. These symptoms being due to pressure, relief is brought about by making a defect in bone and dura through which the brain may protrude in the form of a cerebral hernia—by *decompression*, in other words. The mere prolongation of life, unless it be made better worth the living, does not justify such a measure, and consequently when there are extensive paralyses through invasion of important tracts by the growth, or when blindness is already present, one naturally refrains from such a temporizing measure. All operating neurologists have doubtless gone through the period of decompressing tumor cases in the vain hope of restoring some degree of vision after its total failure. Indeed, when atrophy has once begun, it may be impossible even to hold the process at a standstill.

Decompressive operations, on the other hand, performed early

in the disease are often of brilliant success. Since many tumors are slowly progressive, all symptoms may disappear even for years after such an operation, and, provided the tumor occupies a silent area, patients may resume their occupations with apparent normal vigor and health. Thus, paradoxical though it may sound, cases of brain tumor which present general symptoms alone, with no localizing signs whatever, are, in a certain respect, the most favorable ones for surgical intervention. I have had a number of patients in whom, after decompressive measures, there has been a practical disappearance of all symptoms over periods up to five years—not perhaps surprising when we consider that tumors which lead to no mechanical disturbance may last for years even in an intact cranium. Again, in a number of these cases localizing symptoms have appeared some months after the simple decompression, and it then has been possible to locate and

FIGS. 128 and 129.—HERNIA TWO MONTHS AND EIGHTEEN MONTHS AFTER DECOMPRESSION FOR TUMOR.

Showing great size which may be attained by protrusion, when unprotected by muscle. Case of mesially placed growth of left occipital lobe.

remove the growth, the patient, in the interval, having been spared much suffering and his vision having been saved. There are a number of conditions which militate against the success of these decompressive measures; among them obstructive hydrocephalus, for when this is present the cranial defect simply allows the ventricle to fill to a greater extent and does not greatly lessen the cerebral tension.

There are various methods advocated for the making of these cranial defects, and it may be said in passing that not only a defect in the bone, but incision or removal of the dura as well, are essential to their efficacy. Depending on the size of the growth and the degree of cerebral tension, there will be a protrusion of the exposed cortex of variable size. Whether from edema, from vascular strangulation, or from rupture of nerve tracts, the function of that part of the cortex which protrudes is more or less interfered with, and hence it is desira-

ble, as Sänger has emphasized, to decompress over a comparatively unimportant area, his choice in right-handed patients being the right postcentral field. There are, however, disadvantages in this, since, protected only by scalp, should the protrusion become large there results either an obtrusive swelling (Figs. 128 and 129) or, worse, the incision may break down and a fungus cerebri result. It is for this reason that a decompression hernia should be protected by taking advantage of the temporal muscle for cases of cerebral tumor, and of the suboccipital muscles for cases of subtentorial growths, which, owing to the subdivision of the cranial chamber made by the tentorium, had best be decompressed at the occipital base.

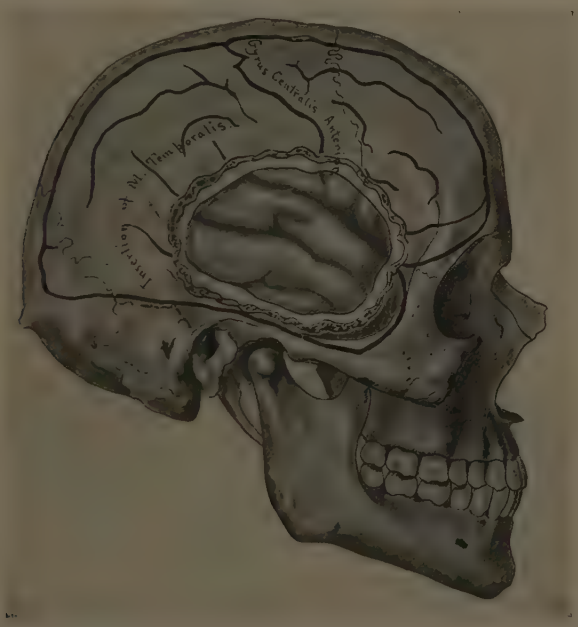


FIG. 130.—SKETCH TO SHOW THE RELATION OF THE BONE DEFECT TO THE UNDERLYING CORTEX AND THE AREA OF THE LATTER WHICH WILL HERNIATE IN THE SUBTEMPORAL DECOMPRESSIVE OPERATION.

The temporal muscle overlies a fairly silent area of cortex (Fig. 130), especially on the right side; the underlying bone is for the most part thin; and a unilateral defect will usually suffice to relieve pressure symptoms, though in some cases a bilateral operation may be necessary. I prefer to make the operation by an intermuscular method (Fig. 131), splitting the temporal fibers. This allows of a perfect closure and the muscle prevents undue and unsightly protrusion. Care must be taken not to injure the meningeal artery in rongeuring away the bone, and not to divide the vessel when the dura is incised.

The view has been held by some neurologists that it is better, in case a tumor is localizable, to decompress directly over it. This does not seem wise, particularly in vascular tumors, for the disloca-

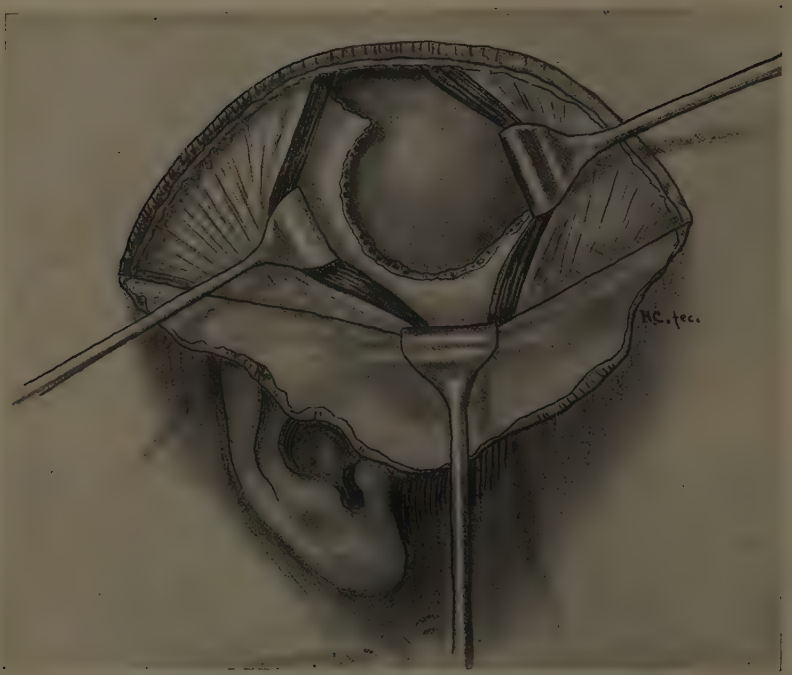
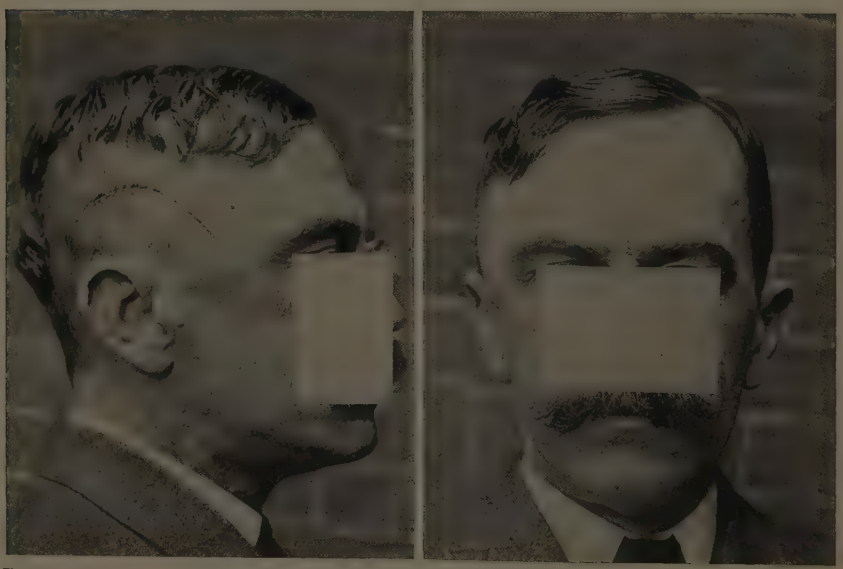


FIG. 131.—SKETCH OF THE INTERMUSCULOTEMPORAL FIELD OF OPERATION.
Showing exposure with subtemporal bone defect partly made.



FIGS. 132 and 133.—CASE OF UNLOCALIZABLE TUMOR SHOWING SITUATION AND RESULT OF SUBTEMPORAL DECOMPRESSION TEN DAYS AFTER OPERATION.
Note inconspicuous degree of bulging. Immediate subsidence of all symptoms.

tion of the brain which follows may lead to extensive hemorrhages into the growth, owing to rupture of its delicate vessels. I usually

prefer, in these cases of tumor of doubtful removability, to perform a subtemporal decompression first, in order to relieve symptoms (Figs. 132 and 133), and after some days or weeks to expose the tumor itself, for if it prove to be inoperable the bone flap can then be replaced.

In tumors which unquestionably lie in the subtentorial region a suboccipital decompression is preferable (Fig. 134), for only in this way is there a chance that the change of position of the structures may lead to a re-opening of the ventricular exit in case obstructive hydrocephalus is present. I think the operation should be a bilateral one, with the removal of a wide area of bone; namely, from the superior crest to the foramen magnum (including the removal of its dorsal half), and from mastoid to mastoid (Fig. 154). The exposed dura is then removed entirely. If properly preserved the muscles and galea can be resutured in layers. Drainage is undesirable and should never be employed in any decompressive operation (for technic, see p. 275).

FIG. 134.—CASE OF SUBOCCIPITAL DECOMPRESSION, SHOWING "CROSS-BOW" INCISION AND SLIGHT, WELL-PROTECTED HERNIA.

A tumor was successfully removed from the left lateral lobe two years after this decompressive operation. (Cf. Fig. 153, p. 274.)

Curative Operations.—Though yearly increasing in number; though new areas of the brain are, with our better powers of diagnosis, constantly being invaded; and though, on the whole, operations are being undertaken at an earlier stage of the disease, nevertheless the number of successful cases of extirpation with permanent and complete restoration of function still remains lamentably few. They are, however, certain to increase with the correction of what Horsley calls "the vulgar error of regarding surgical treatment as a *dernier ressort*." Statistics, gathered largely from post-mortem records, regarding the removability of tumors, are most misleading, and it is perhaps remarkable that the oft-quoted figures from 4 per cent. (Oppenheim) to 9 per cent. (Starr) are as large as they are since they represent, for the most part, terminal conditions.

Granting that a tumor is localizable and in an approachable situation, there are a number of questions to be taken seriously into account in considering the advisability of its attempted removal. Among them are: (1) What is the nature of the tumor?—a matter which concerns the possibility of so outlining the growth that recurrence is unlikely, for a partial removal is worse than nothing. (2) How great a loss of function has the tumor already produced? (3) Will an improve-

ment in symptoms follow its removal or, on the other hand, will symptoms be increased? In other words: in how far are they due to actual destruction and in how far merely to pressure?

These questions cannot all be answered concisely, but it may be said that there is small hope of permanent recovery from an infiltrating tumor; that the wide area of removal necessitated in its attempted extirpation increases the functional loss already present; and that unless it be small it had best be treated by a simple decompression, in the remote hope of its undergoing degeneration. If, however, a tumor is encapsulated, it is remarkable in how great a degree function may be restored; showing that pressure alone has had much to do with the paralyses. In one case of removal of a large cystic subcortical tumor of the postcentral region I have seen a rapid and almost complete recovery from the pre-existing hemianesthesia and hemiplegia. Then, too, the experience of the laboratory with experimental extirpation, as well as of the clinic in removing areas of the pre- and postcentral convolutions for epilepsy show us how great is the functional restorative power of the brain. This applies even more to the association fields than to those registering sensation, particularly of the special senses, and those presiding over motion; and it is particularly true of the cerebellum. As Horsley has emphasized, however, one rarely, if ever, needs to remove normal tissue, whether of cerebrum or cerebellum, in order to gain access to a growth: areas of the brain may have to be incised or pushed aside for this purpose, rarely extirpated.

Though the details of operative methods will be left for a later section, certain principles of especial importance in operations for the removal of tumors must be considered here.

A Primary Defect Versus an Osteoplastic Flap.—By whatever method the opening in the skull may be made, a wide area of dura must be exposed, so that when opened there will be a generous margin of normal cortex on all sides of the growth. It is Horsley's custom, I believe, in all cases to remove the bone entirely, purposely leaving a large defect, and one hesitates to diverge in any respect from his unquestionable leadership in these matters. I much prefer, however, for work on the exposed parts of the cerebrum, to make a large osteoplastic flap, so that, if possible, it may be replaced after the tumor has been removed. If decompression is urgently called for, a subtemporal operation may be performed at an earlier sitting, or else the subtemporal bone may be rongeured away after the flap has been elevated. Only in the suboccipital approach to the cerebellum is the bone deliberately removed on both sides of the median line as a primary step.

In operations on the vault the flap is made above a *tourniquet* by a special technic to be described, so that there is little, if any, bleeding; and it is most unusual ever to see any evidence of shock occasioned by the procedure. I am aware that it is a common belief that cranial operations are prone to cause "shock," but it is a personal conviction, due to the careful observation of blood pressure changes in these operations, that so-called shock, in the majority of cases, is due either to loss of blood or to cerebral trauma (concussion) brought on by injudicious methods of entering the skull.

Shall the Operation be Done in One or Two Stages?—One must share in the patient's

aversion to an operation in two sittings, especially if it necessitates, in a weak individual, a second anesthetization after a short interval of a few days. Operative shock is the chief reason, as I understand it, of advocacy of the "two-stage" operation. If, however, there is no undue loss of blood and no change in arterial tension shown by a blood-pressure apparatus, a somewhat prolonged single anesthetization is, I think, preferable to a repeated one.

For these reasons I have, until recently, adhered to a one-stage procedure. Bleeding, however, in tumor cases sometimes occurs in spite of all precautions, and if difficult to control may require the placement of gauze over the dura, the closure of the wound, and a second-stage operation. Owing to this complication and to the fact that the patient took his anesthetic badly, I was forced to postpone the opening of the dura in a recent operation. Five days later the wound was reopened, the bone flap reflected, the dural flap made, and a subcortical tumor removed from the parietal lobe without the patient's being aware of any manipulations until he felt the pain of suturing the scalp at the time of closure. I have since had two similar experiences in which a second-stage operation was performed with the administration of primary anesthesia merely for the closure of the scalp wound. Should such a procedure prove to be possible in other cases it will furnish, I believe, a better reason for a two-stage operation than has been heretofore advanced.

The Principle of Dislocation.—There is one factor to be observed in cerebellar operations, particularly for tumors of the lateral recess, which I think is of importance: namely, that of the outward protrusion of one lobe while the other is being pressed to the side; and such a dislocation is only possible when a free bilateral opening in bone and dura has been made with exposure of both lobes. In this way easy access to the tumor is gained, and there is less likelihood of affecting the medullary centers by pressure than in the unilateral method advocated by some surgeons, who have even found it necessary to extirpate a portion of the cerebellar lobe in order to expose these freely accessible tumors. Not only can this *principle of outward dislocation* be used in order to gain more room for intracranial manipulations, but also a *lumbar puncture* with withdrawal of cerebrospinal fluid during the course of an operation may often be helpful to a surprising degree in cases in which the cerebrospinal fluid does not escape through the cranial wound. With an open skull, lumbar puncture can be performed with no risk of fatal medullary compression.

The *technic* of some of the more difficult operations cannot be entered into here, as they are not sufficiently worked out to justify definite conclusions. Thus, Sir Victor Horsley's remarkable experience in the removal of tumors of the pituitary body by an approach under the temporal lobe [1] is not likely to be repeated by other than specialists in neurological surgery. Indeed, it may be said of most operations for brain tumor that for their successful completion they require special training in neurology and an especial technic not likely to be acquired by the general surgeon.

There are certain details which may be mentioned in closing this section, the general technical methods being reserved for a succeeding one. *Position.*—I think it is wise to have the patient placed on the table in the position desired for operation before the anesthetic is administered. This is particularly important in cerebellar cases, in order to assure free respiration, unimpeded by an uncomfortable posture. *Anesthesia.*—Ether, without question, must be regarded, in this country at least, as the anesthetic of choice, for there are certain elements of danger in the lowered blood-pressure of chloroform narcosis which more than offsets the possible lessening of bleeding under this drug. An expert professional anesthetist should be employed. The most painstaking *hemostasis* must be observed in the scalp, in the bone with

[1] Continental surgeons have advocated an approach under the frontal lobes from directly in front, and Krause has once exposed the sella turcica in this way.

wax, and in the brain with sterile cotton. The patient's head should be elevated; the operating-room warm; and a more or less constant hot irrigation (115° F.), as Horsley advocates, may be used to prevent local cooling of the exposed brain. In all cases a *blood-pressure apparatus* should be used and a running record of arterial tension kept, for this furnishes the earliest warning of impending shock. Further, an *artificial respiration apparatus* (incomparably superior to the arm-to-arm method) should be at hand, for an already burdened respiratory center may be thrown out of function during the manipulations of the brain, delicate though they may be; for we have already noted under "Compression" that breathing stops long before cessation of the heart-beat, which under artificial respiration may be kept up indefinitely. A number of patients have been rescued in this way. *Enucleation.*—An encapsulated tumor may be shelled out of its bed, with but little bleeding, by careful manipulations and the proper use of cotton, which I prefer to hot irrigations as a hemostatic. When the cortex is to be incised above a tumor which has not reached the surface, the individual cortical vessels radiating from it must be doubly ligated with delicate strands of split silk and the cortex incised between the ligatures. Below the cortex there is often surprisingly little bleeding. The brain must be carefully separated from the growth with smooth, fairly blunt dissectors, and if bleeding occurs a pledget of cotton is placed in the gap while another side is worked upon. In this way, by slow dissection, the tumor can often be cleanly outlined with but little loss of blood and the production of no shock. The attempt to hurriedly dislocate a tumor outward by plunging fingers into the brain is atrocious. There should be a legal penalty imposed for "speeding" in brain surgery.

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SOME SEQUELAE OF INJURIES AND DISEASES OF THE BRAIN.

Among a multitude of complications which may appear at an early or late date after encephalic lesions, I shall select four for brief consideration here.

1. **Hernia Cerebri and Fungus Cerebri.**—The combination of a defect in the skull and dura and an accompanying increase in intracranial tension, whatever may be its cause, lead to a cerebral hernia or, in other words, to a local protrusion of the exposed area of brain through the defect. When, in addition to this combination of factors, there exists an open wound of the overlying scalp, so that the protruding nervous tissue is exposed, a fungus[1] or prolapsus cerebri results—a much more serious condition, owing to the liability of infection and subsequent meningitis. A protrusion of the brain covered by intact soft parts carries no risk of life and may even save it by warding off fatal compression; a protrusion which becomes exposed, which granulates, necroses, and leaks cerebrospinal fluid, is almost always fatal.

In *tumors* we have just seen that the deliberate establishment of a hernia may be a desirable thing and may serve to relieve the symptoms of brain pressure produced by the increased tension within the unyielding walls of the skull. We have seen, too, that such a relief from pressure may occur by natural processes, either by a hernia, which forms at a point where a growth has led to absorption of the overlying bone, or in the young by the general separation of the sutures. The latter condition represents the most perfect and ideal form of decompression for tumors, and is, indeed, so perfect that no protrusion of cortex occurs through an operative defect made for purposes of exploration under these circumstances.

A widespread but erroneous idea prevails, that under all circumstances the mere exposure of the brain on opening the dura will lead to a protrusion through the dural opening. On the contrary, unless

[1] It may be said that the designation "fungoid" is here confined to herniæ which are denuded of scalp and does not include the so-called fungating tumors which arise from dura or bone, and are usually ulcerated and granulating sarcomata.

there is some abnormal increase in tension, whether from a pre-existing lesion or injuries attributable to the operation, the brain should recede somewhat under the atmospheric pressure. It is to be borne in mind that even though no tumor, hydrocephalus, edema, or other cause of increased tension be present, an increase of brain pressure may be brought about by an improperly conducted operation; for an operative approach associated with trauma which leads to edema or, worse, to cortical lesions will cause a protrusion, and further, venous stasis will do the same thing, whether it be due to a low position of the head or to the congestion produced by a badly taken or poorly administered anesthetic. Such a protrusion during a simple exploratory operation—in epilepsy, for example, when there were no previous tension disturbances—may prove a serious embarrassment to the operative procedure and may interfere particularly with the accurate approximation of the dura at the time of closure. Should this complication occur there are various ways in which it may be overcome: by simple elevation of the head; by pricking the arachnoid membrane and allowing cerebrospinal fluid to escape, which it may do in large amounts, particularly if the condition is due to stasis; or, if these fail, by a lumbar puncture, which will almost invariably lead to a sufficient subsidence of the protrusion to allow the necessary accurate closure of the incised dural edges.

Herniæ established for decompressive purposes in tumor may reach an enormous size if they are unprotected by overlying muscle, and particularly if the growth has caused an obstruction to the outflow of cerebrospinal fluid. A fungus cerebri, formerly a comparatively common sequel of exploratory operations for brain tumors, is to-day rarely seen, owing to the greater efficiency of the present-day methods not only of entering the skull but of closing the operative wound.

In *acute lesions* associated with any degree of cerebral injury a hernia is inevitable, provided there is a defect in the skull and dura. The defect itself may have been of traumatic origin or have been surgically made. Thus a compound fracture of the skull, associated with a dural injury and with contusion or laceration of the brain, leads to a prolapse of brain through the defect; and if the pia and arachnoid have been injured, or if pressure has been sufficient to rupture them, the soft tissue of the encephalon is forced out through the external wound. If intracranial pressure be great this tissue prolapse may occur through even a small cranial defect, such as may be made by a gunshot wound; and in cases of operation for intracranial hemorrhage, as in apoplexy, when there is a high degree of tension, the brain pressure may be so great as to rupture the protecting pia and arachnoid as soon as the dura has been opened.

It is important, therefore, in all operations which disclose tension, to observe the greatest possible care not to injure the leptomeninges in opening the dura. For even the slightest break in these membranes may lead to rupture of the cortex, with subsequent exudation of blood and edema into the tissue and a greatly exaggerated protrusion. Par-

ticularly when there is infection of a prolapse it is remarkable how extreme may be the swelling of even a small portion of the brain tissue. A fungus as large as a fist may be excised and in a few days be replaced by another equally large through the same opening. Large portions of the brain may be lost by gangrene or necrosis of a prolapse. There is apt to be a constant discharge of cerebrospinal fluid and, indeed, the ventricle may often be opened by the process.

In all cases of cortical wounds it is to be remembered not only that a local increase of tension will be the immediate result of an extravasation into the tissues, but that edema, possibly of some days' duration, will also follow. In operations for the removal of brain tumors, as well as in accidental traumatic lesions, swelling, with increase of tension, will result. In tumors this swelling may serve to fill up, in a short time, the large cerebral defect which may have been left by the extirpation, and only after a period of ten to twenty days will there be a gradual recession of the swollen brain leading to a concavity at the seat of the cranial defect in case the bone has been permanently removed.

Inasmuch as a cerebral hernia is solely a mechanical consequence of increased tension, the process is one to be controlled and not one to be combated. To exert pressure against a forming hernia is as obnoxious a practice as the strapping of the head of a hydrocephalic child in the hope of checking the hydrops. A reduction in size of the prolapse by this method serves merely to cause compression symptoms.

Herniæ which are established by intent should be made in such a way and in such a situation that there is no likelihood of their reaching an undue size and no chance of their reopening the closed wound by pressure from within. Herniæ which occur through accidental wounds must be covered, so far as possible, by external soft parts and protected with the greatest care against possible infection during their active stage. They will of themselves subside in time and the protrusion will give place to the depression which is normally present at the seat of a defect when there is no increase of intracranial tension.

It may be mentioned that there normally is present an opening in the cranial chamber; namely, at the foramen magnum, and that a protrusion in varying degree of the neighboring intracranial contents—that is, of medulla and posterior lips of cerebellum—takes place through the opening in all cases of increased tension whose effects reach the subtentorial parts of the brain. (Fig. 118, p. 222.)

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2. **Epilepsy.**—This term, like many another, is traceable to the ancients, and its derivation indicates the existence of a belief in some supernatural agency—a "falling on"—a meaning, as Gowers points out, which is not entirely absent from our "seizure" or "attacks." We have ceased to consider it a "sacred disease" without anatomical lesion, but even now the seizures, regardless of their cause, are apt to be looked upon as the malady itself—so little has our knowledge advanced. Without the loss of consciousness "epilepsy" is a misnomer, and a convulsion is merely one distressing manifestation of a kaleidoscopic variety of cerebral lesions. In epilepsy, as the term has come to be used, either of these cardinal symptoms may be absent, for there may be convulsions without loss of consciousness, or simple lapses of consciousness without convulsion. The term epilepsy, as the name of a disease, must be used grudgingly.

All of our present knowledge, drawn from experimental as well as pathological sources, goes to show that the epileptic fit originates in the motor cortex. A convulsion, epileptiform in type, can, indeed, be elicited by faradization of the normal precentral convolution, so that, by cortical irritation alone, this characterizing symptom of epilepsy can be simulated in the absence of any pathological lesion. Convulsive seizures similarly can be induced by other than mechanical forms of irritation. Thus, the toxemia occurring in renal disease may lead to convulsions (eclampsia); convulsions frequently occur at the time of the first dentition; they may be excited supposedly by reflex irritation from other extracerebral sources, as the gastro-intestinal canal, from errors of refraction, from nasal or aural polypi, etc.; they are a feature of certain morbid states of the central nervous system, designated as hysteria. The epileptiform convulsions characterizing many of these conditions, even when the immediate cause is removed, may persist as "epilepsy," particularly should there be an inherited tendency to nervous diseases and should "the epileptic habit of spontaneous discharges" be acquired.

We are, however, chiefly concerned with epilepsy which is due to definite organic lesions. And here again there is confusion in regard to the large group of so-called idiopathic or essential epilepsies, in which it is often impossible to determine even histological alterations in the cerebral cortex, far from there being any gross lesion; for many adhere to the view that all individuals in whom epilepsy has become established possess some definite organic lesion, however small, which, under varying circumstances, becomes the inciting cause of the motor discharge or attack.

Organic, in contradistinction to idiopathic epilepsy, however, is usually typified by so-called focal or Jacksonian attacks, preceded by a more or less definite aura. This symptomatic differentiation cannot always be relied upon, for cases even of reflex epilepsy may have distinct focal manifestations; and, on the other hand, organic epileptic attacks due to a definite organic lesion may have none.

Etiology and Morbid Anatomy.—As indicated above, nothing definite is known of the pathology of the so-called idiopathic epilepsy.

Cortical gliosis, nuclear changes in the cells, sclerosis of the cornu ammonis, and other encephalic lesions, constitutional disturbances associated with rachitis, a persistent thymus and lymphatic state, and many other conditions have been advanced as causal agents in the disease. On the other hand, a large number of gross lesions, acute or chronic, may be provocative of convulsive seizures which may become established as epilepsy. Thus, acute disturbances, traumatic or inflammatory, which chiefly affect the cortex (an area of encephalitis, the compression of an extradural clot, focal hemorrhages or lacerations of the cortex itself) may lead to a series of epileptiform seizures, indistinguishable from focal or general epilepsy, as the case may be, and which may or may not permanently subside as the lesion heals. Chronic irritation from scars, from corticodural adhesions, from depressed fragments of bone and other foreign agents, or from defects of one sort or another secondary to encephalic injuries, may lead to the so-called traumatic epilepsy. Whether the lesion itself is the source of irritation or the chronic neurogliar changes which it sets up is immaterial.

Epileptic convulsions, often of a general, though usually of a focal type, may follow meningitis, seemingly the result of cortical adhesions; they frequently occur in cerebral syphilis; they are a common symptom of brain tumors, in fact, often the inaugural symptom of those growths which originate in or near the cortex adjoining the central fissure; they may be incited by the cortical changes set up by an area of softening, after thrombosis or embolism; and epileptiform attacks are common in dementia and other degenerative cerebral processes.

Possibly one of the most common forms of injury which leads ultimately to epilepsy is that incidental to parturition—the birth palsies; 60 per cent. of them, according to Gowers, are followed sooner or later by this complication, and when we consider that the cases which later on are recognizable as Little's disease represent necessarily a serious and widespread lesion, and that presumably an enormous number of infants receive at birth some trifling cerebral injury which, from lack of symptoms, is overlooked, may it not be that many cases of so-called idiopathic epilepsy dating from childhood can be safely attributed to the effects of early traumatism?

It may be noted that the motor area of the epileptic's brain seems to be unduly excitable to electrical stimulation, and that focal or general seizures can be elicited on faradization more easily than from the normal cortex.

We may see from these paragraphs that epilepsy or epileptic convulsions may be symptomatic of a great variety of lesions, many of which, at their inception or in an early stage of their progress, may

[1] That there is something back of the lesion itself, some circulatory change, some disturbance with the cerebrospinal fluid circulation, as Kocher believed, or some auto-toxic agent of metabolic origin, which is the torch to set off the discharge, cannot be doubted. Cholin in abnormal quantity has been found in the cerebrospinal fluid of epileptics at the time of the attack and is thought by some to be the exciting agent. In this connection see Julius Donath. Zeit. f. phys. Chemie, 1903, vol. xxxix., p. 526.

have been amenable to relief from surgical measures; and some of them even in a late stage continue to be so.

Symptoms.—From the motor manifestations alone we may divide the cases into two groups: (1) Those in which the convulsion regularly begins in a certain group of muscles, spreading possibly into other groups, and finally involving the entire body (focal or Jacksonian epilepsy), and (2) those cases in which the seizure is general from the outset. Cases included in the second group may, in their earlier history, have presented focal symptoms and still earlier may have been nothing more than "fainting spells." Many cases of epilepsy which may progress in severity to its major form (*grand mal*) may begin with these mild attacks of so-called *petit mal*, and, indeed, in advanced cases a series of these "mild" seizures, with a momentary lapse of consciousness, may alternate with severe general convulsions.

A definitely focal lesion of the cortex situated elsewhere than near the " motor gyrus " may lead to epileptic attacks which are characterized by general convulsions; nevertheless preconvulsive symptoms designated as an *aura* may, even in these cases, serve to point out the primary source of irritation. These symptoms may be of a sensory type and affect either the modalities of common sensation or the special senses. Thus, attacks which originate from the *postcentral* area may be ushered in by paresthesia, numbness and tingling, or burning or painful sensations in an extremity or in the trunk or face; those originating from the *occipital lobe* by visual impressions, lights, or colors; those from a lesion in the *uncinate gyrus* by gustatory or olfactory impressions. There is an *aphasic type*, in which there may be an inaugural disturbance with speech, either on its sensory or motor side; a *psychic type*, in which perverted ideas dominate consciousness and automatic acts may be performed; a *cerebellar type*, characterized by vertigo with opisthotonoid spasms, etc.

When the attacks are due to a lesion which encroaches upon the *precentral convolution* they begin with a focal twitching, which may in some attacks remain limited to the uncontrollable rhythmic movement of a single finger or toe or corner of the mouth, or in others may spread to adjoining groups of muscles, whose movements are subservient to areas of the cortex adjoining that primarily involved in the lesion. Hence, by the spread or "march" of symptoms, the entire musculature of one side of the body, and finally of both sides, may become involved. It is characteristic of many cases of focal epilepsy for the seizures to abort before the convulsion has involved the entire body and before consciousness is lost. The patient, therefore, is often able accurately to describe the progressive steps of an individual attack; and even though the attacks increase in severity and number they always retain their original initial character, unless some alteration by operation or otherwise has been made in the focal lesion.

Though these, in brief, are some of the characterizing features of the seizures in organic epilepsy, it must be emphasized, in accord with Allan Starr, that no sharp line of distinction can be drawn between

them and the symptoms which are present in many of the so-called idiopathic cases.

Diagnosis and Prognosis.—From the history, as well as from associated symptoms, we may often gain some knowledge in cases of focal epilepsy of the underlying lesion, whether it be due to syphilis, to a brain tumor, to a traumatic injury of adult life or dating from birth, or to disease of the cerebral blood-vessels, etc. It is important to do so, if possible, inasmuch as many of these lesions are favorable for surgical measures, and the earlier they are removed the better is the prognosis as regards cessation of the epileptic seizures. It may be said that the longer epilepsy has existed the greater likelihood there is of establishing what we, for better understanding, call "the epileptic habit." In long-standing cases, therefore, even after the removal of some lesion to which the trouble can be definitely attributed—as a depressed spicule of bone, a cyst or tumor, or adhesions—the symptoms are apt to persist even though their evident source of origin has been removed.

Treatment.—From a medicinal standpoint the treatment of the symptom "epilepsy" is a most unsatisfactory one. Aside from those cases which arise in adult life and are definitely due to syphilis, we are practically limited to general hygienic measures, with regulation of the diet, attention to the bowels, careful abstinence from mental fatigue or excitements of all kinds, and to the use of bromids. In their various preparations the bromid salts serve in many cases to inhibit the attacks, and thus symptomatically to benefit the patient. This is particularly true of many of the idiopathic cases; less so in those due to a definite organic lesion. Indeed, it is a familiar experience to find that patients suffering from traumatic epilepsy improve on the withdrawal of bromids, after they have been taken over long periods and have been found ineffectual in completely controlling the seizures. Then there are disadvantages in the drug when taken in large amounts over long periods, for it dulls the intellect, often upsets the digestion, and may apparently lead of itself, apart from the disease for which it is given, to ultimate mental deterioration. Of drugs other than the bromid preparations borax has been given a high place.

An individual attack preceded by a distinct aura may sometimes be averted by a sudden muscular or mental effort, by inhalation of amyl nitrite, by strong smelling salts, or, in case the attack starts in a single extremity, by firmly grasping it or even placing a ligature about it. When the attack is under way the clothes should be loosened and, if it can be done without the exertion of too great force, a gag may be inserted between the teeth to prevent tongue-biting. One not infrequently, however, sees worse lesions of lips and teeth produced in the effort to pry the mouth open than would otherwise have been found in the bitten tongue. Vomiting sometimes occurs at the end of an attack and the patient should be turned on his side to prevent chance inhalation of vomited matter.

In *status epilepticus*, a grave, often fatal condition, in which a series

of fits follow one another without intervening return to consciousness, chloroform should be administered to the point of muscular relaxation and a large dose of chloral hydrate should be given per rectum. Hypodermic injections of hydrobromate of hyoscin or morphin are also recommended.

For the general education and regulation of life of the incurable and idiopathic forms of epilepsy in general, the colony system, such as that established at Sonyea, New York, possesses many obvious advantages.

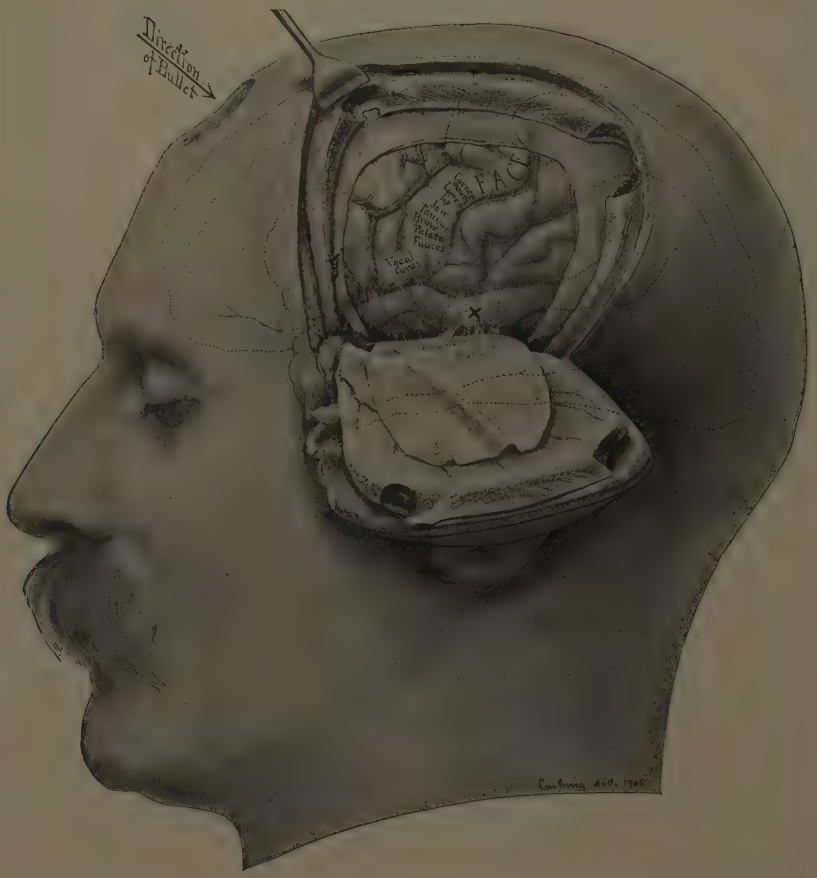

FIG. 135.—DRAWING OF FIELD OF OPERATION IN A CASE OF FOCAL EPILEPSY WITH VOCAL SPEECH AURA, SECONDARY TO A CORTICOMENINGEAL LESION DUE TO HEMORRHAGE, THE RESULT OF A PERFORATING BULLET-WOUND.

Note corticodural adhesions centering at a cortical scar, *X*, under which the missile lay. Results of cortical stimulation are indicated.

Surgical Treatment.—From what has been said of the pathological lesions underlying many cases of epilepsy, it is evident that the condition must often be preventable and that once started it can often be checked by operative measures. It is preventable through proper surgical

treatment of these traumatic lesions, which, unrelieved, lead to epilepsy in a large number of cases. Thus a failure to elevate the fragments in depressed fractures, or to remove cortical clots in case of intracranial hemorrhage, the slow organization of which leads to adhesions, may leave a focus of irritation which could have been avoided. When traumatic epilepsy has once become established there is less chance of operative relief, and it is a common experience, even with such cases as the one depicted (Fig. 135), in which cortical adhesions could be easily separated and a bullet buried just under the surface could be removed, to find that removal of the initial sources of the disturbance does not lead to a cure. Nevertheless in cases of traumatic epilepsy it can be definitely stated that should the attacks present any focal symptom, the patient should be operated upon as soon as possible after their first occurrence, for the likelihood of betterment diminishes rapidly with the long continuance of symptoms; further, that even though the attacks are not completely and permanently stopped by the operation, they are apt to be lessened in severity and their interval prolonged, provided the operation discloses some lesion which can be removed, as adhesions, a depressed fragment of bone, or a foreign body.

It is chiefly toward these cases of traumatic epilepsy that most surgical measures have been directed. As the result of the original injury, often a compound fracture, many of the patients possess a defect in the skull, and it has been supposed by many that closure of the opening would have a beneficial effect. Hence plates of silver, celluloid, or what not, have been fitted into or over the defect and plastic operations of the Müller-König type have been devised to secure a re-formation of bone to close the opening. It is a personal belief that enlargement of the defect, with the assurance gained that there is no depression of fragments about its margin, would be more likely to inhibit the inciting cause than would a successful firm closure of the bony opening. The chief desideratum is to secure an absence of adhesions, and this would only be possible, in case the cortex, meninges, and skull have been bound up together in a cicatricial mass, by covering the cortex with a new dural covering which possesses an intact endothelial surface. A defect of itself, as is well known in other and non-traumatic conditions, bears no ill consequences; but the closure of a defect over an adherent scar embracing cortex and meninges is usually found to have a worse effect than the further enlargement of the opening, for in the latter case, with a fluctuating opening, there is less dragging upon the cortex brought about by the variations in the size of the brain due to the cardiac and respiratory waves.

Less difficult for surgical measures are the traumatic cases, in which, with no cranial deformity or loss of substance, a subdural hemorrhage has occurred, the absorption of which has left adhesions which prove to be the source of irritation. In case they are localizable, that is, if they lead to focal epilepsy, so that they may be exposed and broken down at an early date, there may be no further symptoms. If the operation is carried out carefully and dryly and if the wound is closed

with exact dural approximation, there is no more likelihood of a re-formation of adhesions than after their separation from between serous surfaces elsewhere in the body. The same rules apply to the epileptic attacks brought on by the adhesions after meningitis. I have seen a few remarkable "cures" follow upon the bilateral separation of the widespread filmy adhesions which characterize these conditions. In other cases when, from one cause or another, there has been a simple thickening of the arachnoid without adhesions, I have seen great benefit follow the extensive opening of the arachnoid spaces, accomplished by tearing with a needle the non-vascular membrane as it bridges across the sulci, thus allowing of some local alteration in the cerebrospinal fluid circulation.

Cases of focal epilepsy which owe their origin to the irritation of a new growth are usually cured by its removal, even though a large defect is left, which must undergo a slow process of cicatrization and which would seem consequently a favorable starting-point for a spreading gliosis. In one of my patients, focal epilepsy of a severe and advancing type had for six years been the chief manifestation of the lesion —a subcortical cyst, evidently involving the cortex at the depth of the central fissure—and on its removal the seizures abruptly ceased. It is always to be borne in mind that focal epilepsy may be the only symptom of a new growth arising near the central fissure, and Starr gives this as one reason why all cases of focal epilepsy should be explored upon the first definite appearance of the symptom; for this offers the chance of discovering at an early and removable stage a tumor which otherwise would in time prove fatal.

In cases of focal epilepsy, whether or not a definite lesion has been demonstrated at operation, Horsley long ago advocated the removal by extirpation of that section of the precentral gyrus, stimulation of which serves to produce the same movement as that which ushers in the convulsive discharge. The idea that a circumscribed lesion leads to the focal discharge would naturally suggest this operative measure, in the hope that removal of the group of over-irritable cells would remove the cause and that the resultant scar would not necessarily lead to similar motor discharges. This operation demands of the surgeon especial knowledge, not only of cerebral topography and of the newer methods of cortical stimulation, but also especial skill in performing bloodless extirpations. It has not, however, in its results, proven a method of exceptional value, and the cases suitable for its employment are few. I have extirpated cortical areas from the precentral gyrus, or from the postcentral gyrus when there has been an inaugural sensory aura, in about 15 cases. Some of them have unexpectedly resulted in cures; 1 or 2 that promised to be especially favorable, owing to the circumscribed nature of the initial movement (thumb and corner of mouth), were not benefited.

There are a number of other surgical measures of questionable value which have been not only advocated, but carried out in the attempt to find some method of cure for the general run of cases. They are based

on more or less hypothetical views regarding the immediate causation of the fits; but signal success has not followed their employment.

Two of the more widely followed procedures have been those suggested by Kocher and by Jonnesco. Both of them are based on the belief that sudden alterations in the circulatory supply to the brain, whether from hyperemia or anemia, are in many individuals the precipitating cause of the attacks, and there are many clinical and experimental facts which lend support to this view. Kocher's operation consists in the making of a simple, large defect in the cranium, possibly a bilateral one; Jonnesco's consists in a bilateral removal of the superior cervical ganglia of the sympathetic nerves.

The lesions leading to epilepsy vary so greatly that it is impossible to lay down any definite rules, either for the selection of those cases which may seem suitable for surgical measures or for the method of operating itself. In preparation for this section I have reviewed the records of those cases which in the past five years have been referred to me for surgical treatment and have obtained a late report from those who were subjected to operation.

There have been 128 cases in all, of which number only 59 have been operated upon, showing that there has been a considerable sorting out of unfavorable cases. It is often a matter of mood, however, rather than of intelligent selection, for at times against my better judgment I have been induced to operate and have unexpectedly found and corrected conditions which have apparently resulted in cure. On the other hand, cases promising to be most favorable, both before and at the time of operation, have proven dismal failures.

Of these 59 cases, in 40 the attacks have been focal; in 19 general. There have been 7 cases of epilepsy associated with brain tumor; 24 following birth or infantile palsies of one sort or another with a great variety of lesions, from simple adhesions to large porencephalic defects; 20 following traumatism in the adult, many of them unfortunately of long standing and some who had undergone previous operations; 18 of miscellaneous kind, including hemorrhagic pachymeningitis, hydrocephalus, adhesions following meningitis, syphilis, and a number of "idiopathic" cases with focal symptoms, but no discoverable focal lesions.

Of these 59 cases, 12 have remained free from attacks for periods of from one to five years and hopefully regard themselves as permanently cured. Most of them have received no bromid therapy since the operation. These figures compare almost exactly with Starr's. Of course, cessation of attacks for only a year cannot be regarded as evidence of a "cure." I have had a patient in whom, after a cranial injury, attacks appeared for a time, subsided, and did not reappear until after an interval of forty years.

Of the remainder, 30 express themselves as improved, many of them as "greatly improved." The time since operation varies from five years to six months. The more recent operations can hardly be included for it is an almost invariable rule for patients to feel a subjective im-

provement after operation, even when there is no apparent lessening of attacks. This may be something more than the "effect of the exploration, *per se*," as J. W. White explains it, and may be a result of the cortical exposure, or altered vascular condition, or, more probably, removal of drugs and renewed efforts on the part of the patient to regulate his habits.

In the cases recorded as "improved" there has been a distinct lessening of the attacks in number or severity; in one of them there was a temporary return of seizures after a year and a half. In these cases before the operation the record of seizures[1] varied from one severe attack monthly to many, both mild and severe, in the twenty-four hours. Improvement does not always immediately follow the operation; on the contrary, there may be only a gradual subsidence of the attacks. One notable fact, observed by many, is that patients, whose seizures before the operation were not controlled by bromids, afterward become much more susceptible to the influence of these salts, even in much smaller doses.

In 17 of the 59 cases there was no improvement; 2 of them have since died in *status epilepticus*.

The operations performed in these 59 cases were most variable, including separation of adhesions, 21; extirpation, 13; evacuation and removal of cysts (useless when porencephalic), 6; tumor cases, extirpation, 4, decompression, 6; opening of arachnoid spaces, 9. In several there was a combination of these procedures, together with the establishment of a defect (Kocher) in the cranium.

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[1] In order to fully appreciate any change in the attacks for better or worse, it is necessary for the patient to keep a plotted chart of the seizures both before and after the operation—using particular marks for mild, medium, and severe attacks. Epileptics, whether operated upon or not, should be encouraged to keep such records, for they supply a graphic method of record which enables one to tell at a glance whether or not the therapeutic agents under employment are proving beneficial.

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3. **The Psychoses and Insanity Following Cranial Injuries.**—Aberrant mental processes are a common result of injuries to the head. We may consider (1) their immediate and (2) their late manifestations.

(1) *The Immediate Disturbances.*—In reviewing the symptoms of concussion and contusion some of the acute symptoms have been recorded. After the usual initial period of unconsciousness the patient remains stunned or dazed for a variable period. He suffers from headache; becomes dizzy; is somewhat nauseated on change of position; is often in a dreamy condition of sopor, from which he can be aroused for a few moments with an apparent feeble grasp of his situation, but into which he soon lapses again. He may pass from this dull, stuporous state into an active one, accompanied by violence, delusions, disorientation, and delirium. This condition may become protracted over a period of a few weeks and represents a *primary traumatic insanity.* There is often fever. Forcible restraint of these patients is at times necessary.

Complete recovery after these symptoms with a defective memory of the events connected with them is not unlikely, even in the extreme cases; and it is quite probable that they are often due to states of acute edema. I have seen patients in whom compression symptoms, even to the point of medullary paralysis, were present, and in whom a decompressive operation disclosed an abundance of sterile fluid under pressure (acute serous meningitis).

(2) *The Late or Residual Disturbances.*—These occur in a group of cases which make a satisfactory and early recovery from the injury, but show after-effects—the so-called "post-traumatic neuroses." These patients complain of sensations of pain on pressure or paresthesia of one sort or another, often referred to the seat of the primary external injury. They have attacks of dizziness, irritability, and nervousness. Their traits may change; formerly good natured, they become brooding, moody, introspective, irascible, and even violent at times. They are forgetful, make stupid blunders, are slow of thought, have no power of concentration, and hence their capacity for continuing their former occupation is greatly lessened. There is often excessive sensitiveness of the head to jars or noises, and a stooping posture is not tolerated. Natural sleep is affected. They are most intolerant of alcohol or tobacco in amounts previously taken without ill effect. They are very susceptible to febrile disorders. Though no objective signs accompany these complaints, they are so uniform from case to case that the symptoms cannot be regarded as other than genuine. They are a frequent source of litigation. Epilepsy not uncommonly

occurs and attempted suicide is not unusual. These patients often clearly develop a *secondary traumatic insanity.*

There seems to be no definite relation between any special types of lesion and the particular form of psychosis which may follow. Simple concussion or contusion, with or without definite fracture, fractures of the base or of the convexity, cranial injuries leading to loss of substance or otherwise, gunshot injuries, and other forms of lesion may at times provoke these symptoms in varying grades. No more does there seem to be any definite relation between the situation of the cerebral lesion and the occurrence of these symptoms, though one would suppose that injuries of the frontal lobe would be most likely to lead to them. Doubtless a constitutional peculiarity, inherited weakness, or alcoholism predisposes to post-traumatic psychoses.

No surgeon fails to see a number of these unfortunates. They appear again and again in the same hospital wards, or more often wander from clinic to clinic in the vain hope of securing some surgical relief for their miseries. Many of them, particularly when cranial defects or local scars are present, are subjected to operation and reoperation at various hands. They are received with scant welcome, and when weary of their complaint the ward discharges them "untreated," with a diagnosis of traumatic neurasthenia or neurosis. They finally wear out the patience and sympathy even of their home people. Little wonder that there is often an attempt, sometimes successful, at self-destruction.

Treatment.—As is the case with many of the sequels of cranial injury, the treatment is largely preventive. We have seen that, particularly with the traumatic cerebral lesions of infancy, an immediate "recovery" without operative intervention may take place, and yet residual disturbances of serious import, appreciated only after some months, may remain. The same is true of adult lesions. Many of them doubtless are beyond the reach of our present methods of operative treatment, but as many more are within reach. The let-well-enough-alone policy is a wise one to follow under many conditions, particularly when it is evident that recovery from the immediate effects of an injury will take place without surgical interference; but when there is a likelihood that mental deterioration may follow such a "recovery," it is short-sighted to neglect any measures which may possibly lessen the probability of its occurrence.

Preventive measures are limited to the period immediately following the injury. Needless to say, when there is a palpable fracture of the convexity it must receive attention, particularly when it is comminuted and when the dura has been injured. If there is doubt as to the presence of a depression it is better to explore and determine the fact. Subdural clots in particular must be carefully removed, and if possible a primary or a secondary closure of the dura should be made over a cortical laceration. Unless it will be in an obtrusive situation or on the forehead, it is better to err on the side of leaving a defect in the skull than otherwise.

More important are the cases without evident fracture, which are usually left to run their own course. This is particularly true of basal fractures: for when they are accompanied by subdural hemorrhages, or when acute edema is present, leading to compression symptoms, a decompressive operation with evacuation of fluid, bloody or otherwise, and the establishment of a permanent defect under one or both temporal muscles, often serves not only to promptly check the immediate symptoms, but distinctly lessens the liability of the late "neuroses." I am fully convinced that properly conducted operations are thus of the greatest prophylactic value. Both Bullard and Spiller, in their studies of the late consequences of cerebral injuries, have pointed out that the post-traumatic neuroses—other factors being equal—are less likely to follow in cases which have been subjected to operation than in those which have not.

Aside from operation in the acute stage, too great emphasis cannot be laid on absolute rest and enforced quiet for a long period after the injury. These patients, like others, are apt to be hurried out of the hospital; and an attempt at too early a date to resume their former activities often results in a disastrous nervous breakdown.

Operations for residual symptoms in their late stages are often most disappointing in their results. There is often some subjective improvement after the removal of a scar, the repair of a defect, trephining under a local point of tenderness, etc.; but usually the same symptoms or others reappear and the patient again seeks a willing surgeon, until operation becomes a habit with him. Though in isolated cases remarkable and sometimes unaccountable cures follow surgical measures, even in patients having pronounced symptoms of long standing, they are most exceptional.

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Insanity and Imbecility.—It is unaccountable that an idea should have arisen attributing microcephalus and other conditions of congenital imperfection, as well as those of development arrested by disease, to a premature closure of the cranial bones. All of our knowl-

edge goes to show that an early closure of fontanel and suture is due to a primary failure of growth of the encephalon; not the reverse, a failure of growth due to a primary closure. Experiments by d'Abundo and others show that animals whose skulls in early life have been firmly enclosed, so that there is no possibility of cerebral expansion, cannot survive. Even firmly closed sutures may give way before the pressure of growth. We see this even in young adult life, as a separation of sutures in acquired hydrocephalus, and in cases of tumor growth.

The introduction in 1891 of linear craniotomy, which has led to innumerable operations said to have been followed by an improvement in mentality, is a lamentable instance of the *furor operandi* running away with surgical judgment. In this connection Abraham Jacobi's address, "Non Nocere," delivered in 1894 before the International Medical Congress in Rome, should be read.

Educational rather than surgical or medicinal measures are indicated in these unfortunate cases. There has been a high mortality in these operations, and though death cannot be lamented, the surgeon is not a barbarian to execute the helpless. It will become the duty of the state to care for these mentally deficient children, for the sake both of child and parents.

Only when epilepsy or hydrocephalus is superadded to the defect can we have any expectation—and that a remote one—of benefiting the condition. An exploration may be justifiable in doubtful cases, to determine the nature of the lesion and in order to certify the prognosis—not with any expectation of allowing the brain to grow.

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4. **Cranial Defects and Their Closure.**—Are cranial defects of themselves prejudicial to the subsequent welfare of the brain? This question is such a many-sided one that a definite answer for all cases cannot possibly be given. There is a tendency on the part of many surgeons to regard the pulsating gap in the cranium as in a measure the cause of some of the distressing post-traumatic symptoms which have been recorded in the preceding sections, and hence to regard it as something to be solidly closed if possible.

Arguments may be advanced for and against this view. There is no doubt but that we see a great number of patients suffering from headaches, local discomforts, mental derangement, epilepsy, and the like, in whom, from loss of bone at the time of injury or from subsequent operations, there has resulted a defect too large for closure by natural processes of repair. Unless it can be shown that defects in general, including those not of traumatic origin, are attended with ill effects, and further, when they are of traumatic origin, that their closure leads to an improvement in existing symptoms, it is natural to infer that

the symptoms accompanying a defect are merely an expression of the cerebral lesion which was coincident with the cranial injury.

One or more defects normally are present in a child's skull. We, with malice aforethought, purposely make defects in certain operations,—as upon the Gasserian ganglion or when bone is removed for purposes of decompression. Kocher, indeed, goes so far as to believe that they exert a beneficial influence in cases of traumatic epilepsy, so that in certain instances he even advocates their establishment as a therapeutic measure. Further, defects even of large size and resulting from serious traumatic injuries may not be accompanied by any untoward symptoms. A remarkable example of this has been reported by H. P. Frost (Fig. 136). For twenty-six years after an injury which resulted not only in an extensive laceration with sloughing of a large part of the right

FIG. 136.—EXTENSIVE CRANIAL DEFECT WITH SURVIVAL FOR FORTY-ONE YEARS (case of H. P. Frost).

hemisphere, but in leaving a defect in the cranium measuring 5 by 6 inches, the patient had no symptoms beyond a slight sense of fulness in the head. Then a progressively developing palsy came on, leading to the patient's death in an asylum fifteen years later. Certainly the cranial defect in a case of this kind played a small part in leading to the late mental deterioration, nor could its closure have benefited the patient in any way.

I am myself inclined to the view that closure of a defect should be limited to those cases in which it is in an obtrusive situation and makes an unsightly deformity; to those in which local pain or tenderness promises to be lessened; or occasionally when the patient has an obsession in regard to its presence.

So far as the condition may affect, in one way or another, the progress of symptoms which result from the cerebral lesion, there may be advan-

tages in having an opening. It is presumably a wound of the dura associated with the defect which is of chief consequence, for without this the loss of bone should have no more effect on the brain than has the fontanel of the infant's skull. When the dura has been injured as well as the brain, an attached scar will form, whether or not there be a solid bony covering; and it is debatable whether the irritation of such a scar is less when there is a defect which allows it to pulsate with the brain or when there is a solid covering to which it adheres. The restoration of a smooth and unattached dural surface is of chief moment, and if this can be accomplished it makes little difference whether the bone defect be closed or not. A neurogliar proliferation which may have its origin in a cortical scar will progress, whether there is an intact or open cranium. There are many, however, who believe that closure of a gap in the skull resulting from traumatism is of the highest importance. Stieda, voicing von Bramann, has recently reported a series of 48 cases from the latter's clinic in favor of this view.

Should a closure of the defect be considered advisable there are several measures open. At the time of the injury suspicious fragments may be left in place (*primary implantation*), with drainage as a safeguard should necrosis occur; oftentimes even a large, entirely dislocated fragment may partially or totally heal in place. If, owing to laceration of the scalp, the condition of the wound is such that replacement seems unwise at the time, we may wait until it has become covered with healthy granulations, on which the preserved fragment, after sterilization, may be replaced (*intermediary implantation*). Finally, if a wound which was compound has been allowed to completely cicatrize over the defect and it becomes desirable to close it, we may select one of two methods. By the *heteroplastic method* a shell of bone, with its overlying periosteum, is taken from elsewhere, as from the inner surface of the tibia, and implanted in the reopened wound. It is no longer a common practice to use heterogeneous materials for this purpose, as celluloid or silver plates, though nature sometimes endures their insertion with charitable tolerance. By the *autoplastic method* a flap is made, including the scalp and the underlying periosteum, together with adherent fragments of the outer table, which have been chipped away with a chisel or fine saw (Nicoladoni) as the flap is elevated. This flap is then rotated on its pedicle, so as to close in the freshly denuded bone defect. The surface from which the flap has been taken is left to heal slowly or it may be covered at any time by a skin graft. This is the so-called autoplastic method of Müller and König—an improvement on a method of closing defects introduced in 1884 by Durante, which made use of the principle of *autoplastie par glissement* introduced by Ollier.

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THE TECHNIC OF INTRACRANIAL OPERATIONS.*

Under this heading shall be briefly considered some general principles which concern the various methods of opening the cranial chamber. These measures, so far as they relate to particular lesions, have already been reviewed in their appropriate sections—namely, in connection with birth palsies, with fractures, with hydrocephalus, with

Fig. 137.—Female Skull from Peru with Operative Defect which had Healed under the Protection of a Silver Plate found in Place. (Bureau of Ethnology.)

abscess, with intracranial hemorrhage, with brain tumor, etc. It remains to speak more specifically of the technical methods of performing craniectomy and craniotomy—in other words, of operations in which a portion of the skull is permanently removed and of those in which it is only momentarily displaced.

Two thousand years ago the "Father of Medicine" commented on the great antiquity of the operation of trephining; to-day we are still better able to appreciate its great age—not from mere tradition, but from the mute evidence of ante-mortem trephining furnished by certain

* For the operations on the Gasserian ganglion, see chapter by Dr. Charles H. Frazier in Vol. V.

prehistoric skulls of the Stone Age unearthed in modern times (Figs. 137 and 138). And it is quite possible that these primitive flint-stone trepanations, whether they were done for the sake of letting out "spiritual demons," of securing amulets, or of elevating actual traumatic depressions, were attended with no higher a mortality than was the case with similar operations for more modern "demons" of known or conjectural pathology—that is, up to the time of Lister. The hand trephine itself, particularly in its modern form, was known to and employed by the ancients, and in the Renaissance, as Paré's plates show, there had come into use a complete equipment of tools differing

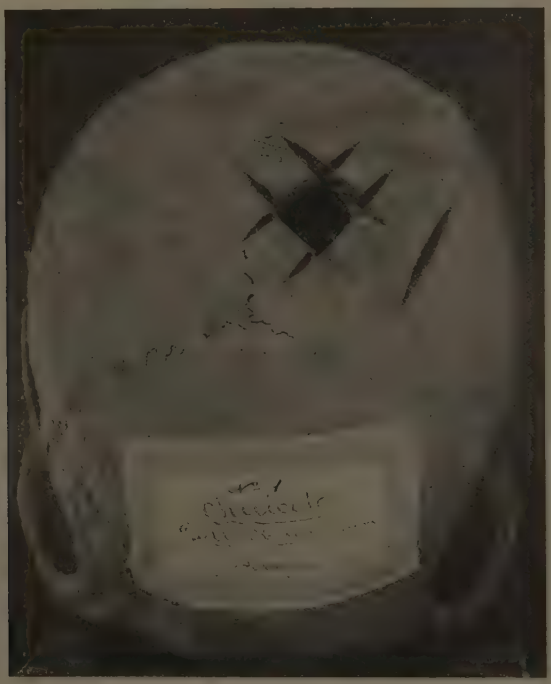

FIG. 138.—PERUVIAN SKULL SHOWING TREPANATION BY RECTILINEAR INCISION. First cut for another opening; probably fatal. (Bureau of Ethnology).

in material and in detail of construction rather than in principle from those which we now employ. Only one thing is lacking, and that an unessential thing—a new form of power to drive the tool, which the electromotor can now supply.

These earlier trepanations were confined to the removal of bone—to partial craniectomies, in other words—and were performed from time to time, as can be learned from the many historical essays on the subject, in scant or in great number, according to the example and precept of the leading writers on surgical matters during the successive epochs of the past five hundred years. Thus it was popularized by Paré in the sixteenth century and again by Petit and by Le Dran and

by Percival Pott, who advocated trephining in all cranial fractures as a prophylactic measure. Dupuytren and Malgaigne and Astley Cooper discouraged its use. The circular trephine, occasionally with a brace and bit attachment, but usually of the simple single-hand pattern, has withstood the test of time as the favorite and safest instrument with which to make a primary operative opening in the skull.

With the introduction of aseptic surgery, which allowed the dura to be opened with impunity; with the understanding that there was a definite differentiation of function in the various parts of the brain which would enable lesions to be localized, and with the epochal advancement in technic which we owe to Wagner, the character of cranial surgery has been changed perhaps more than that of any other part of the body: for the cases of temporary osteoplastic resection of the skull for the exposure of cerebral disease far outnumber the openings made with trephine and rongeur directed largely toward the treatment of traumatic injuries of the skull itself. Little wonder that, before this method of resection was introduced with its wide area of exposure, operations to disclose pathological lesions proved unsatisfactory to a degree, especially when we consider that they were largely confined to lesions in the supposed excitomotor field, which, as we have seen, has been given its proper delineation within a few years only.

The Osteoplastic Craniotomy.—Taking this operation as typical of the more difficult modern cranial procedures, the general principles of technic of cerebral surgery in general may be made to center about its description. Many of the views to be expressed are purely personal ones and are given with the full knowledge that the instruments and operative details found satisfactory to one individual may be entirely unsuited to the operative requirements of others. Special training and familiarity with a given set of instruments engenders facility; unfamiliarity even with a better tool, awkwardness. Aware that I may be using to-morrow a different method from that to be described and which Da Costa has called a "combined method," I nevertheless am assured that it is characterized by safety; and avoidance of operative accidents in the approach to a cerebral lesion is, after all, the matter of chief moment.

General Methods of Preparation.—There is no ward preparation beyond abstinence from food and insuring what should under other circumstances be a daily occurrence—a normal evacuation of the bowels. Patients are too often weakened and made uncomfortable by a purge which acts the morning of operation. The scalp, which may have been shampooed, is shaved just before the operation—a duty incumbent on the surgeon in case of a nervous patient or a child. There has never been an infection, even of a stitch in the scalp, in something over 300 cranial operations in the writer's series. (Many operators prefer to have the scalp shaved and treated antiseptically in the ward on the preceding day; some even advocate a double preparation.) After shaving there may be a preliminary cleansing of the scalp with soap and water and a soft brush, after which the head is wrapped

in a wet bichlorid towel; the final preparation is deferred until after the anesthetic.

Position on the Table.—It is a great advantage, though not a practice common to many, to place the patient on the table in the position most favorable for the operation before administering the anesthetic. It shortens the time as well as the depth of anesthetization, for a change of position from stretcher to table requires a degree of narcosis greater than needed for operative purposes; it insures a comfortable position for the patient and thus obviates the strains, backache, and so forth, which the handling of a relaxed body engenders. It is particularly important to oberve this rule in case the cerebellum or occipital lobes are to be exposed.

Many operators have a particular form of head-rest for all cranial operations, and Horsley, Frazier, Morestin, and others have described table extensions for this purpose. For the usual operations on the vault, however, I find that small, flat, solid pillows or sand-bags are all that are necessary to turn and hold the head in the desired position; on the other hand, I find a head extension necessary for cerebellar work, chiefly to insure free respiration. Thus do surgeons' views differ. Whatever form of table be used, however, it is desirable to have the head-end capable of being raised or lowered at will.

The Anesthetic.—Regardless of the drug to be used, it is essential that it be administered by an expert, preferably by one who makes this his specialty. Many of the conditions for which these operations are done are associated with cardiovascular and respiratory disturbances of cerebral origin, and the greatest care must be exercised lest a further burden be imposed by the anesthetic.

In all serious or questionable cases the patient's pulse and blood pressure, first recorded in the ward, should be followed throughout the entire procedure by a *blood-pressure apparatus* and the observations recorded on a plotted chart. Only in this way can we gain any idea of physiological disturbances—whether given manipulations are leading to shock, whether there is a fall of blood pressure from loss of blood, whether the slowed pulse is due to compression, and so on. A further necessity is an *artificial respiration apparatus*, to be immediately put into use in case there is failure of an already burdened respiratory center, either from the anesthetic, from loss of blood, or from additional compression due to cerebral manipulations.

Sir Victor Horsley, as is well known, is a strong advocate of chloroform combined with a preliminary hypodermic of morphin. Only a small amount of the drug is required, except during the early and closing periods of the anesthetization, and there is less likelihood of subsequent vomiting than when ether is used. It is taken smoothly, without cyanosis, and, furthermore, tends to lower the blood pressure; hence there is said to be less bleeding during the operation. In this country, where chloroform is doubtless administered less well than ether, the latter is the anesthetic of choice at most hands, the primary

stage often being induced with ethyl chlorid. I believe, with Kocher, that there is an element of risk in the lowering of blood pressure by chloroform; and it is perhaps debatable whether this is not a more certain danger than the more active bleeding said to occur under ether; a drug which tends to hold the blood pressure high. Having had a fatality from chloroform, I use it far less frequently in cranial operations than formerly, restricting its use largely to children.

The question of the anesthetic in a two-stage operation is an especially serious one. Chloroform here would perhaps be less dangerous than a repeated etherization. Local anesthesia may at times be employed, though infiltration of the scalp is difficult. I have learned that no anesthetic whatsoever need be required for a second-stage operation limited to manipulations of dura and brain after re-reflecting the original bone flap.

Preparation of the Operative Field.—With the patient anesthetized and in proper position on the table, the final cleansing is done; for this alcohol and 1:1000 bichlorid solution suffice.

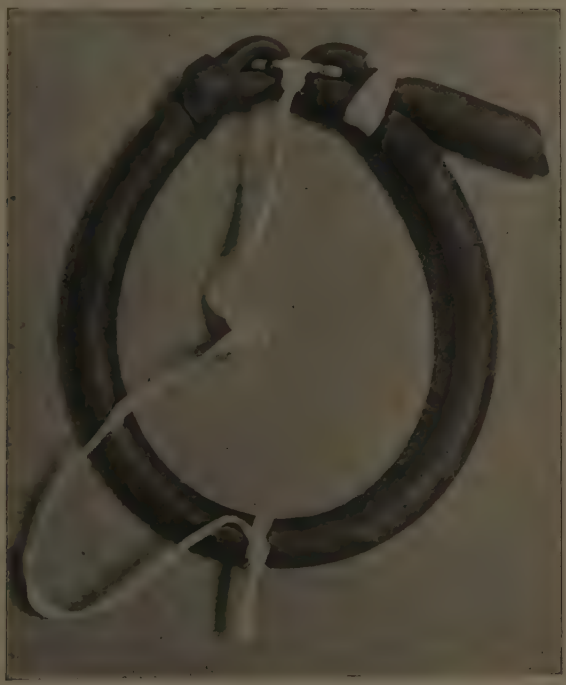

FIG. 139.—AUTHOR'S FORM OF ADJUSTABLE CRANIAL TOURNIQUET, WITH TAPES APPLIED.

It is my practice at this stage, before the landmarks are obscured by the covering of operative sheets and towels, to outline the proposed flap on the scalp with a superficial cut of the scalpel. Those who have by long practice familiarized themselves with craniocerebral topography can mark out the main fissures on the scalp with no greater margin of

error than when measurements are employed. Furthermore, as a large opening is to be made, the accurate determination on the scalp of the point overlying a given center is to-day less essential than formerly, when an attempt was made to approach it directly through a small trephine opening. Those who are less familiar with the topography of the brain will need to mark out these fissures by the aid of some one of the craniometers or rules of measurement which have been described (p. 167). As this is somewhat time-consuming, many prefer with an indelible pencil to delineate these landmarks on the shaved scalp the day before.

With the proposed flap thus outlined and the head raised by a hand under the back of the neck, a broad square of wet bichlorid gauze is thrown over the entire head and over this is placed a *tourniquet.*

For the *control of hemorrhage from the scalp* numerous forms of tourniquet have been advocated. Many use a simple rubber tube or

Fig. 140.—Cranial Tourniquet in Position over Gauze Cap.

Esmarch bandage, both of which are difficult to apply and to fasten without slips in the aseptic technic; Crile uses a rubber dam over the entire scalp, which is thus rendered bloodless; I formerly used a pneumatic tourniquet, but have finally come to a form of rubber ring (Fig. 139), which is snapped over the head from glabella to suboccipital region and which has a median tape to prevent its slipping over the eyes (Fig. 140). This ring, with its tape of proper length, should have been measured before the operation, and, having been boiled, it is applied by the operator and an assistant. Usually all bleeding from the scalp is controlled by the tourniquet, though in certain cases of tumor with marked intracranial stasis some of the veins on the concave side of the incision, receiving blood from the skull, may have to be clamped. Special forceps have been designed for this purpose by Nicholson, Howzel, and Chipault. Other methods of controlling the vessels of the scalp have been advocated; as (1) preliminary ligation

or temporary closure (Crile) of the carotid; (2) the blocking by three mass ligatures of tissue, including temporal, occipital, and supra-orbital arteries; and (3) the enclosure of the proposed incision by a running suture passed through the scalp on each side of it with the purpose of leaving an anemic band of tissue (Heidenhain).

With a proper arrangement of towels and, finally, a large operative sheet which covers the etherizer like a tent, the field is prepared, leaving exposed little more than the area encompassed by the preliminary incision.

The Osteoplastic Flap.—In the line previously scratched on the scalp the incision is made through gauze and soft parts down to the skull, and when the bone is exposed it can be opened in a number of different ways. It may be recalled that in the original operation as described by Wagner (1889) the flap was outlined with mallet and chisel, and Chipault, Keen, and many others followed his lead. Keen long employed a particular form of angular gouge, with which the incision was quickly and skilfully made through the greater thickness of the skull, the flap being finally loosened by a few blows, which served to break such portions of the inner table as had escaped division. Küster has recently advocated a chisel of different form for the same purpose.

Most operators object to these methods on the score of possible concussion even from the glancing blows which are given.

Fig. 141.—Doyen's Hand-saw.

Toison (1891) suggested the division of the bone with a chain saw passed between primary trephine openings, with cutting of the bone from within outward. This remains a first principle. Obalinski (1897) recommended for this purpose the flexible wire saw (introduced by Gigli, in 1897, for obstetrical purposes). A linear cut of 2 or 3 mm. width through the full thickness of the bone, may be made with biting forceps of Montenovesi or Doyen pattern, or with the cutting hooks introduced by Dahlgren and De Vilbiss. These instruments progress slowly, but they are almost certain not to injure the dura and have the advantage of biting outward, so that there is little, if any, jar to the brain. Flexible wire saws may be used, that perfected by Gigli being the best. As it cuts from within outward and when taut straightens on the arc of the cranial circle, the saw must be guarded in order to protect the dura from injury. Similarly, the bone may be cut between the primary openings by sawing with a straight hand saw from without inward, and Doyen has devised a special saw (Fig. 141) with a guard for this purpose. It is a dangerous tool in inexperienced hands.

There are, further, certain craniotomes, which cut in a circular fashion

by swinging the blade about a fixed point, and which may be used to incise scalp as well as bone. The Stellwagen instrument (*Annals of Surgery*, 1902) has been highly praised by Philadelphia surgeons. A French instrument of similar type was described by Codivilla in 1900 (*Revue de chirurgie*). Though no preliminary trephine opening is needed, these methods possess the disadvantage of cutting from without inward, and as there is no guard, the dura is likely to be injured by these *craniotomes à mouvement circulaire*, unless the membrane is approached with the greatest caution.

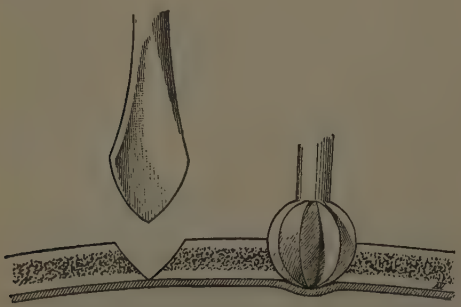

FIG. 142.—SHOWING THE ACTION OF DOYEN'S PERFORATOR AND FRAISE (Marion).

The electromotor has been employed to furnish the driving power for a number of instruments which possess a circular or spherical form and so can revolve, such as burrs (Fig. 142), trephines, and circular saws (of which there are a number of patterns, Van Arsdale's, Powell's, Marsland's, and Doyen's). It has led, furthermore, to the invention of a revolving tool or fraise with spiral cutting edges, which is used by some operators. Cryer, in 1897 (Fig. 143), Sudeck, in 1900, and Sykes have all described similar instruments of this type, and though useful for certain purposes they possess the disadvantage for osteoplastic work of cutting such a wide slot that the replaced flap subsequently rests on the dura instead of on the bone edges. In the Doyen type of motor (Fig. 144) there is a long flexible arm between the motor and

FIG. 143.—CRYER'S SPIRAL OSTEOTOME.

the revolving tool, which is thus driven from a distance, as in the usual form of dental engine. Borchardt (1906) has made some modifications of the apparatus, and Bercut (1904) and Hartley (1907) have made the further great improvement of having the cutting tool directly connected with the motor, which, weighing only 8 or 9 pounds and being capable of sterilization, is itself held in the operator's hands. Hartley has devised also new forms of perforators with serrated edges.

Surgeons who use electromotive force for osteoplastic operations are able to work very rapidly, and if this does not mean added risk of accident it is desirable. However, having witnessed, twice from a Doyen circular saw (Fig. 145) and once from a Cryer drill, what I regard

as a most serious accident—namely, the division of bone and dura at the same time, owing to the fact that the guide of the speeding instrument

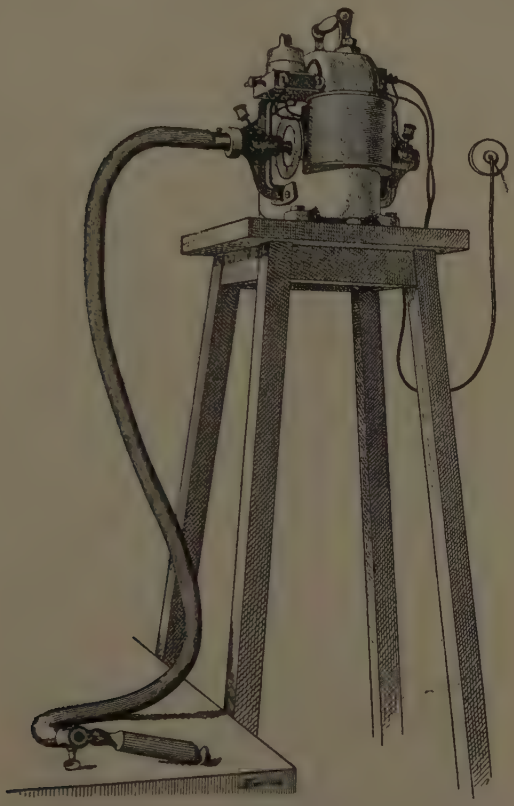

FIG. 144.—DOYEN'S MOTOR FOR CRANIAL OPERATIONS (Marion).

worked its way through the adherent membrane instead of separating it from the skull—I have clung to the somewhat slower, but certainly less dangerous operation by hand-driven instruments.

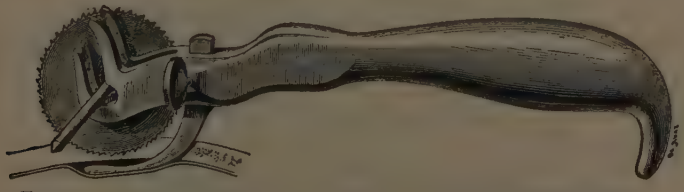

FIG. 145.—DOYEN'S CIRCULAR SAW SHOWING DURAL PROTECTOR (Marion).

The methods of procedure which suit my own personal needs may be described.

The Osteoplastic Procedure.—This combines the following principles: Of *division between primary openings* (Toison); of incision by an *advancing instrument*

from a single opening; of making *all cuts from within outward;* of leaving *a beveled flap.*

A primary opening through the thickest part of the exposed cranium, usually near the parietal eminence, is made with a hand trephine which should be of generous

Fig. 146.—Crown of Beveled Trephine with Loose Central Pin, having Thumb-piece to Prevent its Dropping out unless Desired.

size with a crown of fully 2½ cm. (Fig. 146). I prefer a trephine of the Galt conical pattern with a beveled edge; it is the safest instrument and obviates the necessity

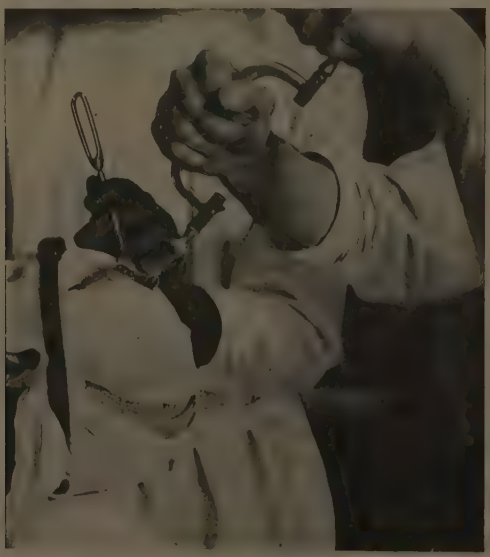

Fig. 147.—Doyen's Burr in Use during Operation.

of an extractor (*tire-fond*) for the button, since, owing to the width of the superficial cut, it can easily be tilted out. In France the old form of cylindrical trepan is still

in general use. Bleeding from diploëtic vessels in certain cases of tumor may be severe. A fatal case, indeed, of this sort has been reported by Ransohoff. It may be controlled by the proper use of Horsley's wax, with which the beveled teeth of the trephine may be filled. One or more secondary openings (one is usually sufficient) at the upper edge of the incision are made with a Doyen burr (Fig. 147). With a long-handled blunt dissector or dural separator introduced through the large trephine opening the dura is separated from the bone between these openings. On withdrawing the dissector the intradural pressure suffices to press dura against bone again and thus to stop the bleeding. From the two trephine openings the lateral edges of the flap are then cut downward toward the base, in line with the skin incision. The first ½ inch of these lateral cuts is made with Montenovesi forceps with a 3 mm. incision, followed by the Dahlgren forceps (Fig. 148), as the thinner bone near the temporal region is approached. A Gigli wire saw (Fig. 149) is then passed on a guide (of which there are numerous forms) between the two primary openings, and

Fig. 148.—Dahlgren Forceps used for Incision of Lateral Edges of Bone Flap when approaching Thinner Portion of Cranium in Temporal Region.

the mesial edge of the flap is cut on a broad bevel (cf. Fig. 135). (This is an important detail, for it enables the subsequent solid replacement of the flap without danger of its being driven inward by a snug pressure bandage.)

The flap is then forced back by the insertion of blunt instruments around the edges and is broken across at its base. As Hartley has emphasized, all flaps made on the cranial vault should radiate toward the temporal bone as a base, since this is the thinnest part of the calvarium and most easily broken. Provided the flap includes the region of the pterion the meningeal artery may be torn, owing to its having channeled the broken bone. The vessel should be ligated at its lowest point of exposure by making at a distance a small opening in the dura through which a grooved dissector is inserted and on which the curved needle should be passed to avoid the chance injury of some cortical vessel. Bleeding from the expansions of the lateral sinus, in case they have been exposed by a high flap, is best controlled by the pressure of sterile absorbent cotton, pledgets of which I find to be as valuable as a hemostatic

agent for the intracranial part of the work as is wax for the bone itself. Horsley uses hot saline or weak bichlorid irrigations.

The Intracranial Procedures.—At this stage, if there has been a fall of blood pressure from loss of blood, the further progress of the operation, especially in tumor cases, may well be postponed for a second session. The question of a two-stage operation and the possibility of a second stage without anesthesia has been considered under the treatment of tumors. If there is no contra-indication on this score the dura is opened in a line concentric with the bone incision, leaving plenty of margin for subsequent suture (Fig. 150). The membrane should be incised on a grooved director, especially if there is increased tension, lest the pia-arachnoid be injured. The incision should not be made too near the median line, lest the edges of the parasinoidal expansions, or the veins entering them, be wounded. If the mesial edge of the hemisphere is to be exposed it is well to open the dura in this direction by a separate radial cut and if necessary to rongeur away some of the bone toward the median line. This is preferable to an attempt at exposure of the mesial edge (foot area), through the primary osteoplastic flap—a procedure necessarily attended with a great loss of blood.

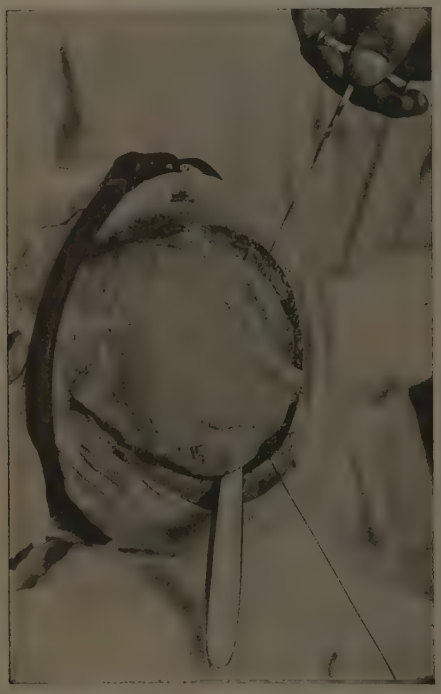

FIG. 149.—SHOWING GIGLI WIRE SAW IN USE FOR MAKING BEVELED MESIAL EDGE OF FLAP, WITH DURAL GUARD INTRODUCED THROUGH THE TWO CRANIAL OPENINGS.

If the expected lesion is not disclosed and if the topography is not perfectly clear the fissura centralis may have to be determined by faradization of the cortex. A long glass unipolar electrode carrying a fine platinum wire core, coiled into a spiral at the end (Fig. 151) according to Sherrington's plan, in order to obviate puncturing the pia-arachnoid, is used for stimulation. The other pole is attached to an extremity, preferably on the homolateral side. The current should be just strong enough to contract exposed muscle—some of the temporal fibers are usually available for this test. If there is an abundance of cerebrospinal fluid in the arachnoid spaces it must be evacuated by pricking the membrane as it bridges the sulci, and further the patient must not be too deeply under the anesthetic. No motor cortex, unless there is complete degeneration of the pyramidal tract, fails to give responses if these precautions are observed.

If an incision of the cortex is necessary, whether for exploration, for extirpation of an area in focal epilepsy, or for the removal of brain tumors, the cortical vessels to be divided must first be ligated on each side of the proposed incision, which should, if possible, be confined to the exposed surface of a convolution and should not cross a sulcus. The finest strands of split silk, preferably black, should be used for these ligatures, and they should be passed around the vessels with delicate curved French needles which are introduced and emerge in non-vascular areas. With these pre-

cautions the subcortical manipulations can usually be conducted with but little loss of blood, even in most cases of tumor extirpation. Tumors which have approached and involved the cortex must be surrounded by a similarly placed double row of ligatures, between which the incision is made. Subsequent dissections are made with blunt instruments and momentary pressure of cotton pledgets will usually check the oozing.

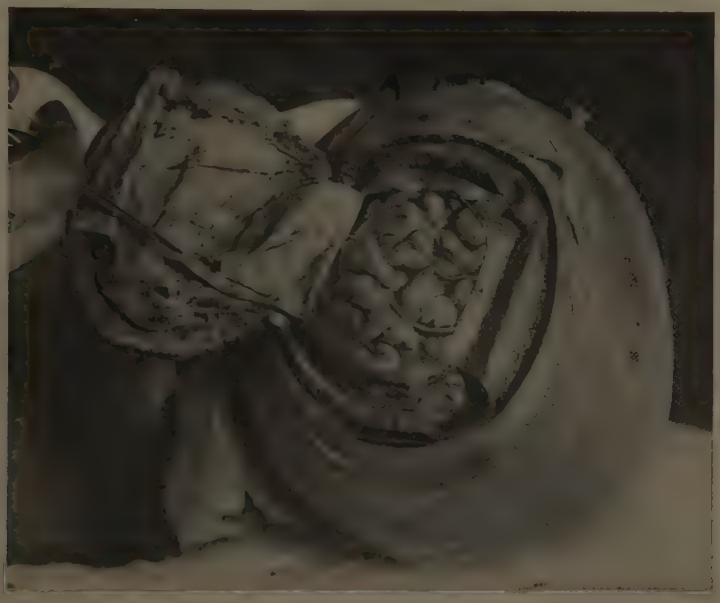

FIG. 150.—OSTEOPLASTIC FLAP AND DURA REFLECTED.
Note broad bevel of upper edge of bone flap, also concentric rather than superimposed openings through scalp, cranium, and dura.

A brain which tends to protrude may sometimes be dropped back by elevation of the head and trunk or by evacuating cerebrospinal fluid. This can at times be accomplished by opening the arachnoid spaces and by milking out the fluid; at other times a lumbar puncture may be necessary, and the removal of fluid in this way

FIG. 151.—SHOWING TERMINAL AND CONNECTION OF AUTHOR'S ELECTRODE (¾ natural size).
Instrument should be 16 inches or more in length.

during the course of an operation is of great help under many circumstances, and is free from the danger which attends a similar proceeding when the skull is closed.

Closure.—Unless an irremovable growth indicates the necessity of permanent decompression, an accurate approximation of the dura in its two layers is desirable; this should be painstakingly done, to prevent the formation of adhesions or their re-formation if they have been found and divided, and have been pro-

ductive of symptoms, as in epilepsy. If there is a large cortical defect, as after the removal of a growth, or if the brain has receded from its normal level, the space may well be filled with warm salt solution before closing the dura. The bone flap is solidly replaced and the scalp is in turn accurately approximated in a broad surface. It is well to draw together the galea aponeurotica by a few buried sutures before closing the outer layer. For the latter, many use a continuous suture, which has the advantage of speed. Inasmuch as the closure in many cases is completed before the tourniquet is removed, I feel the need of a more accurate and solid approximation. This is done by rapidly placing about the incision a series of straight, round-pointed cambric needles, which serve to keep the edges everted as each suture is tied and thus to assure a ridge of tissue with a flat approximation which prevents subsequent bleeding from the vessels of the scalp (Fig. 152).

Fig. 152.—Author's Method of Closing Scalp before Removal of Tourniquet. Note ridge of tissue made by sutures when tied.

Drainage is occasionally advisable—perhaps in 20 per cent. of the cases—but it should be avoided if possible. It is necessitated by constant oozing from the exposed parasinoidal sinuses, for otherwise an extradural clot may form. Marion drains directly through the center of the flap, in which a new opening has been drilled. I prefer to take advantage of the trephine openings already made at the upper angles of the flap. The drains, of cigarette form, covered with protective gauze so that they may be easily withdrawn, are led out, not through the original incision, but through puncture wounds made through the scalp 2 cm. to the outer side; this insures an oblique passage, which can be occluded by pressure in case there should be a tendency for cerebrospinal fluid to escape after the drains have been withdrawn. Kocher has devised small silver tubes for drainage in similar fashion, and they serve the purpose admirably.

The wound is partly dressed and pressure is applied before the tourniquet is removed: then an abundant dressing with an outer starched bandage is employed. The ears should be carefully protected with cotton to prevent discomfort from pressure.

The first dressing is made in forty-eight hours, when the drains, if used, and all the sutures are removed.

Special Operations.—Although these osteoplastic resections typify the methods of approaching the brain in a large percentage of our cases, they are not particularly applicable to operations elsewhere than upon the vault, nor are they necessary in cases in which from the first it is evident that bone must be permanently removed for decompressive purposes. Certain principles relating to these special operations may deserve mention.

Suboccipital Operations.—For the exposure of subtentorial lesions (such as tumors of the cerebellum or of the lateral recess, a basilar meningitis to be drained, the freeing of adhesions about the fourth ventricle resultant to an old inflammation, etc.) the principles of tourniquet and bone flap are not applicable. In this situation, just as under the temporal muscle, owing to the possibility of subsequent firm closure under muscle, there is less reason for preservation of bone. Though many surgeons place the patient on the side for these operations, I much prefer a symmetrical, face-down position, particularly as a bilateral exposure is usually called for. This position interferes greatly with respiration unless the shoulders are held away from the table so as to

FIG. 153.—AUTHOR'S OUTRIGGER FOR CEREBELLAR OPERATIONS WITH SHOULDER SUPPORT TO ALLOW FOR RESPIRATORY MOVEMENTS.
Note unattached head crutch. Subject in position.

allow of free thoracic movements, and consequently, for these cases I have devised a table extension with shoulder supports and a separate crutch with a horseshoe-shaped top in which the forehead and cheek-bones comfortably rest (Fig. 153). The anesthetic is sprayed against a mask attached under the "horseshoe."

It has been mentioned in the section on tumors that a bilateral exposure of both cerebellar lobes is desirable to allow of dislocation outward of the normal lobe during the manipulations of the other. Hence I prefer a symmetrical form of approach, and find that a median incision, which divides the soft parts down not only to occiput, but to the spinous processes of the upper cervical vertebræ, in addition to the usual curvilinear cut over the occipital ridge ("cross-bow" incision,

Fig. 154), gives additional room, owing to the lateral reflection of the flaps. A fringe of muscle and aponeurosis together with galea is carefully preserved at the upper edge for subsequent union by suture with the reflected muscle flaps. The bone is bared and, after making bilateral primary openings, is rongeured away—upward, so as to expose the lateral sinus on each side; across the median line, leaving intact the bone over the torcular; and then downward, so as to include the pos-

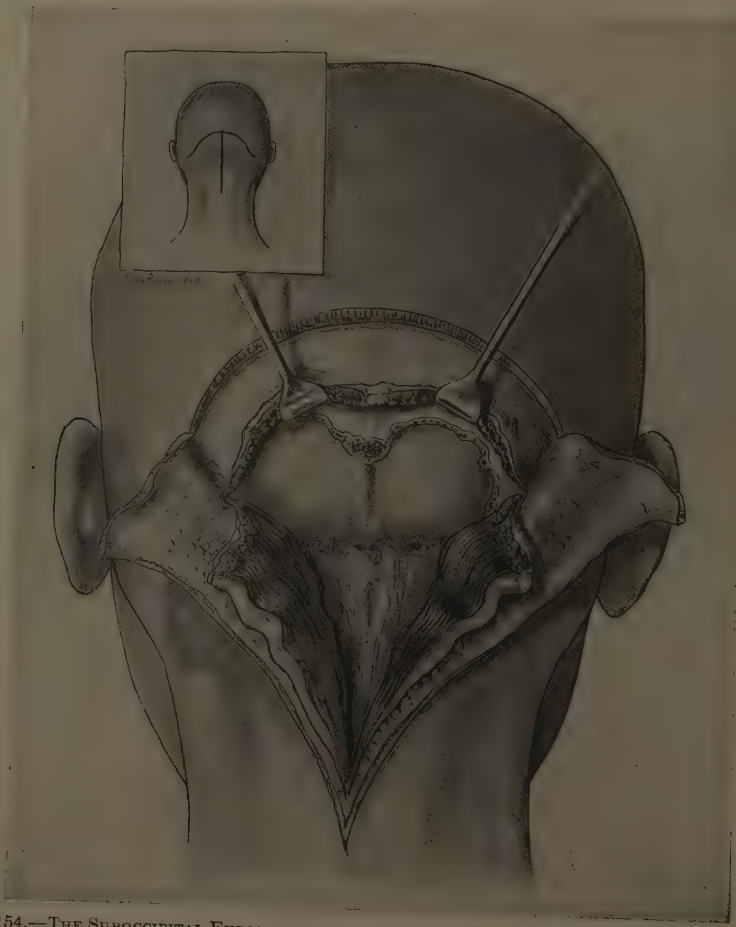

Fig. 154.—The Suboccipital Exposure showing Opening Partly made and Author's "Cross-bow" Incision.

terior half of the foramen magnum. The dura is then widely opened and the midoccipital sinus, if present, is ligated.

This opening, through the possibility of cerebellar dislocation, gives a wide area of exposure, either of the fourth ventricle or of the structures in the cerebellopontine angle; and it is desirable, not only for exploration, but for decompression of incurable tumors in this situation, that it be bilateral. There are certain points in the bone where hem-

orrhage may be met with in these operations, and especial care must be taken at the torcular and at the approach to the mastoid processes. Intracranially a large vein often bridges across the subdural space at the side of the cerebellum, injury to which should be avoided if possible.

Temporal Operations.—Operations either for decompression purposes, or in exploration for hemorrhage, tumor, or abscess in the temporal lobe, or for lesions in the middle cranial fossa, are conveniently carried out by simple splitting of the temporal muscle without division of the fibers. Here again, as in the occipital operation, there is no reason for the preservation of the bone, as there remains a secure muscular protection, which prevents too great bulging in case of increased tension, or an obtrusive and deforming depression in its absence. The incision through the scalp may be made parallel to the muscle-fibers or as a curved incision (Fig. 132) across them. In removing the bone, flat-bladed rongeur forceps are necessary, as the muscle cannot be lifted far away from the skull, and care must be taken not to injure the meningeal in case it lies in a canal at the lower angle of the parietal bone. A large defect giving free exposure of the temporal lobe may be made in this way (Fig. 131, p. 236).

Should it be necessary to bring into view the base of the skull, as in operations upon the Gasserian ganglion or for tumors in its neighborhood, it is better to divide the muscle-fibers without attempting a splitting operation.

These basilar operations through the temporal region may be carried so far inward as to expose the hypophysis. A view at this depth, however, requires such a degree of elevation of the brain that it is necessary to have a large cranial opening in order to allow of dislocation outward, which obviates, in a measure, the danger of compression effects. As conducted by Horsley in his remarkable series of cases, this is an intradural operation conducted, after making a wide opening in the skull, directly under the temporal lobe: after its exposure the new growth situated in the sella turcica is removed with the proper form of curet.

Frontal operations may be required for the exposure of lesions of the orbital or mesial surfaces of the frontal lobe or anterior end of the corpus callosum. An approach to the pituitary fossa has also been attempted by Krause directly under the frontal lobes after turning down a large frontal bone flap. Similar methods have been suggested by Kiliani (1904) and by Duret (1905) while Hartley (1907) advocates a bilateral flap with a pedicle in each temporal fossa. Here, too, a great deal of room for dislocation is necessary, and it would seem that the chance of frontal-lobe injury, far more serious than an equal degree of bruising of the temporal lobe, would make Horsley's route preferable.

These, like many other of the more serious and dangerous of the modern intracranial operations, should, for the time being and until their veriest detail is established on an unquestioned basis, rest in the hands alone of those specially trained in the conduct of cerebral

operations. The advance of neurological surgery is greatly impeded by the prevailing impression in regard to its dangers and general futility—an impression due in large measure to the unsuccessful attempts of the untrained and inexpert.

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CHAPTER XXXVII.

SURGERY OF THE NECK.

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CHICAGO.

ANATOMIC CONSIDERATIONS.

The embryology of the neck must be understood before studying the various abnormities. The gross anatomy is not less important. Bony and muscular landmarks are very plainly laid out. The field is so overcrowded with vital organs, the great vessels, trachea, esophagus, thoracic ducts, cranial, cervical, and sympathetic nerves, enclosed in complex planes and partitions of fascia and muscle, that the simplest operations may involve the dissection among structures whose injury would be fatal.

It might be added that the special physiology of head and neck circulation and resulting improvements in technic, as worked out by Crile, must be well understood before any operator can hope for the best results in the surgery of the neck.

EMBRYONAL CYSTS AND FISTULAE OF THE NECK.

Until Ascheron, in 1832, discovered the connection of the fetal branchial clefts with congenital fistulæ, little was known or written of them. It remained for Luschka, Roser, Koenig, and others to discover the real congenital nature of certain obscure swellings, cysts, and fistulæ which occurred later in life and prove their real fetal origin.

Embryology of Branchial Cysts.—There are four branchial clefts in the four-weeks' fetus, the analogues of the gills of fishes, with four intervening bars called branchial arches (see Figs. 155 and 156). The bars (5, 6, 7, 8, Fig. 156) are called respectively the mandibular and hyoid bars, visceral bars, and first and second branchial arches. Of the intervening clefts (1, 2, 3, 4, Fig. 156), only the first should persist, forming the hyomandibular cleft, from which develop the ear, auditory canal, and Eustachian tube, etc. The other three clefts should coalesce in fetal life, leaving the neck smooth. When this does not occur, we find congenital cysts, called branchial cysts or fistulæ. These may or may not open directly into the pharynx from the outside. It is to be noted that hare-lip and facial clefts described in Chapter XLIII are also due to failure of the mandibular bars to coalesce—*i. e.*, in the middle line.

It is not considered by embryologists that the fetal clefts are fissures

in mammals, entirely through from the skin to the pharynx, like gills. They are merely grooves lined by hypoblast within and epiblast without, separated by a layer of mesoblast. Clinically, however, congenital

FIG. 155.—BRANCHIAL ARCHES AND CLEFTS IN HUMAN EMBRYO.

fistulæ may be complete epithelial cavities from skin through to pharynx, giving rise to at least five types of abnormities about the human neck:

FIG. 156.—VERTICAL SECTION THROUGH PHARYNX IN HUMAN EMBRYO.

1. Complete branchial fistulæ (outer and inner openings; opening complete). 2. Incomplete external fistulæ (outer opening only). 3. Incomplete internal fistulæ (inner opening only). 4. Branchial cysts (neither outer nor inner opening). 5. Branchial dermoids.

Internally, the four locations corresponding to the branchial clefts are slight sulci on the pharynx or natural grooves, viz.:

1. First pharyngeal groove (tube entrance, etc.). 2. Second groove (Rosenmueller's sinus, tonsillar sinus, etc.). 3. A fold (not well marked) in front of the laryngeal nerve. 4. Fourth groove (fundus branchialis, sinus pyriformis).

FIG. 157.—DOUBLE BRANCHIAL FISTULA.
Probes in lower openings.

When persistent and abnormal, these inner sinuses cause congenital sacs and pockets, which may develop fistulæ, as reported by Koenig and Virchow, pointing internally, around the Eustachian tube, tonsil, etc.

FIG. 158.—FOUR-MONTHS' FETUS, WITH TWO LATERAL FISTULÆ AND RUDIMENTARY "CERVICAL AURICLE."
Bristles in orifices of clefts

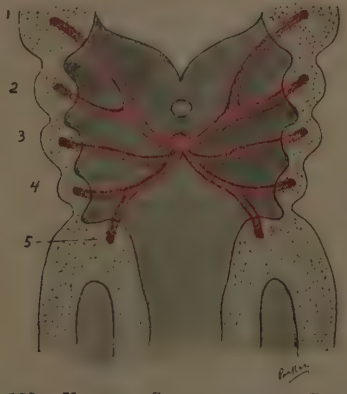


FIG. 159.—VERTICAL SECTION THROUGH PHARYNX, HUMAN EMBRYO. (His.)
1, 2, 3, 4, Gill arches, each containing an aortic arch; 5, fifth aortic arch.

These are not the only congenital cysts, however, due to the clefts. Just as the hyomandibular or first cleft forms the auditory canal and has the ear or pinna at its posterior end, so the other three branchial

clefts sometimes form small false auricles which persist on the side of the neck at their posterior ends in the form of rudiments of cartilage, and sometimes little hairless or pigmented spots. Such congenital deformities are called "cervical auricles" by Knox, Pearce-Gould, and other observers.

Thyroglossal Ducts.—Turning to the median fistulæ, we now come to another form, the thyroglossal or thyrolingual duct, which resembles the branchial cysts, but is of different fetal origin, being connected embryologically with the thyroid gland.

Embryology of Thyroglossal Duct.—Morgagni and, later, Bochdalek early described a blind pouch or depression on the dorsum of the

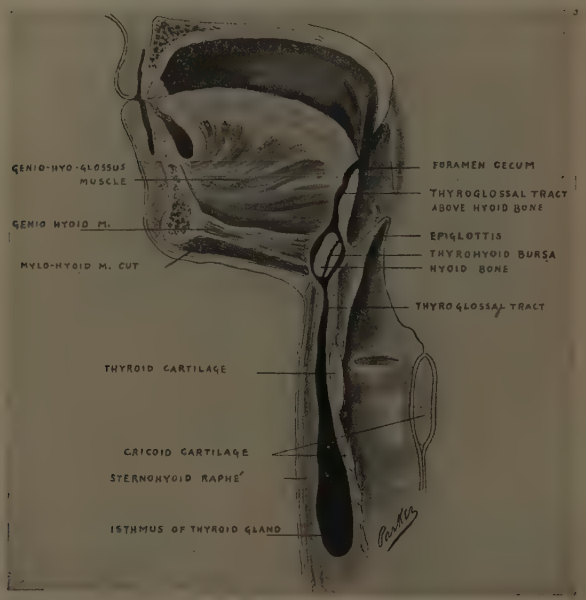


FIG. 160.—THYROGLOSSAL TRACT AND ITS RELATIONS.

tongue, called the foramen cecum. This marks the outlet of an obliterated canal, which in fetal life is an epithelial blind pouch. His, by dissection of human embryos, proved the existence of such a duct, and showed that it is a stage in the development of the thyroid gland. In five-weeks' embryos of 7.5 mm. size he found the thyroid a mere vesicle, developing on the back of the tongue. The glandular acini appear at eight weeks, at which time the vesicle becomes bilobar, with an isthmus. Mueller and Koelliker also found gland tissue in eight weeks. Horsley found gland secretion in twelve weeks. Podade found thyroidal colloid matter in a five-months' fetus.

Developing in the embryo in the location called the sulcus arcuatus, we find what Minot calls a "slender, hollow pedicle" at this groove, between the tissue about to form the epiglottis and the tuberculum impar, which develops later into the tongue. The obliterated upper

end of this hollow pedicle is later the foramen cecum on the back of the tongue. We may definitely locate here the anlage (embryonic nucleus) of the thyroid gland. It thus appears that the thyroid sinks and leaves the tongue normally obliterating its duct. In some mammals (dogs) and fishes (sharks), Woelfler, Meuron, and Van Bemmelen found that the thyroid sometimes sank as low as the arch of the aorta, but never in man below the top of the sternum. Unobliterated portions of this descending canal with a lining of epithelium form congenital thyroglossal tracts or cysts or "ducts." The last term is objected to by Butlin on the ground that it is not a true duct, as it has no such function.

When these displaced remnants contain thyroid-gland tissue, they become "accessory thyroids," as described on another page.

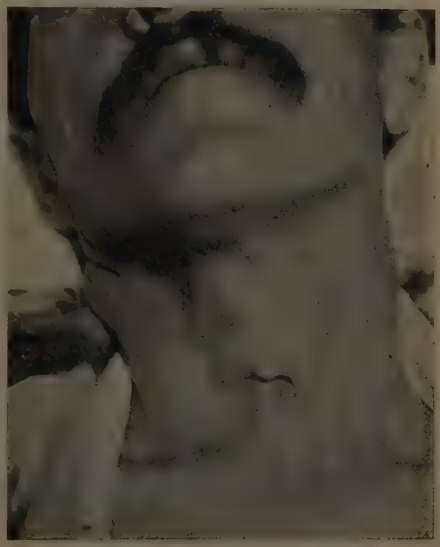


FIG. 161.—THYROGLOSSAL FISTULA. Valve formation at lower end.

Symptoms and Diagnosis.—The congenital fistulæ do not always cause symptoms, and may not be discovered until some distention and irritation with mucous hyaline or mucopurulent discharge has called attention to them. They may escape attention up to adult life. After forming a permanent fistulous opening they remain as somewhat cord-like or slightly indurated tracks leading inward. Their location is between the anterior borders of the two sternomastoids in most cases.

Occupying the location of the clefts in lateral fistulæ and of the thyroglossal duct in median fistulæ, their fixed location helps to distinguish them from other cystic diseases causing fistulæ, such as lymphatic, hydatid, or retention-cyst sinuses. They may simulate abscess or phlegmon in case of obstruction and inflammation. By means of colored injections and fine, flexible probes information as to the direction and extent of the epithelial cavity can be obtained; also sweet substances may be injected to test for openings into the pharynx. The orifices of branchial fistulæ are often minute points difficult to see. Small round depressions with central conical orifices have been noted and more often fissured orifices having valvular lip-shaped outlets, as in Fig. 161. The finest sounds or bristle-like probes may be needed to detect them or the openings may be large and free. Hochenegg calls attention to a significant sign, the great sensitiveness of these epithelial-lined canals to the probe. Almost always the contact starts a spasmodic cough, as if the probe had touched the interior of the larynx

or trachea. This prevents satisfactory sounding by probes in some cases, unless by cocainizing the canal.

FIG. 162.—TUMOR IN SUBMENTAL REGION IN THYROGLOSSAL CYST.

Treatment.—The treatment of lateral and median fistulæ is difficult by operation. In some the lining is so intimately connected with the great vessels and deep spaces that attempts at removal are inadvisable. Partial removal leads to recurrence, cyst formation, and disappointment. Careful attention to the drainage and cleansing of the cavity often is followed by complete arrest of discharge. The sinus ceases to secrete an excess of mucus, and the lumen, though not obliterated, shrinks to minute size, so that little or no trouble remains.

Treatment by injection of caustics to destroy the lining is followed by failure in most cases, on account of the multiplication of folds and sinuses of the epithelium which the agents fail to reach. Their use has not been advised by those who have given them the most extended trials, as few or no cures were obtained.

In spite of the great difficulty and sometimes the impossibility of extirpating these fistulæ by operation, this still remains the most scientific curative resource. Where a long scar is not objectionable, and in certain fistulæ not too intimately connected with the vessel sheaths, a complete excision can be done from the external orifice to the inner pharyngeal opening. Such an excision results in a complete and permanent cure. Attention should here be called to the important structures between which the fistula passes. From the pharyngeal or tonsillar region it crosses in its course downward the pharyngeal and hypoglossal nerves, and passes under the stylopharyn-

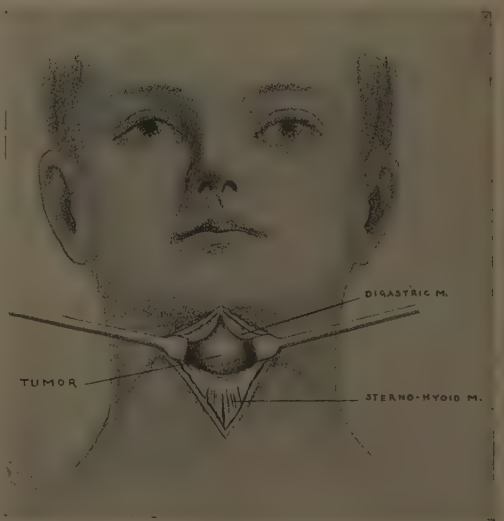


FIG. 163.—OPERATION FOR THYROGLOSSAL DUCT. (J. B. Murphy.)

geus and styloglossus muscles, emerging alongside the great vessels and passing between the external and internal carotids across the digastric muscle to the hyoid region. It then finds exit between the sternomastoid borders or near one of them; sometimes this outlet is

FIG. 164.—BRANCHIAL FISTULA DISSECTED TO SHOW ANATOMIC RELATIONS.

as low as the top of the sternum. To remove such a tract, if adherent to its surroundings, is difficult or impossible, but if not too adherent to the vessel walls experienced surgeons are able entirely to extirpate them, including their inner and outer orifices.

FIG. 165.—SPECIMEN OF BRANCHIAL SINUS.

Dissected out entire by J. W. MacIntosh, Jefferson Medical College Hospital. Note that its length was about 50 per cent. greater (nearly 9 cm.) before being puckered on the probe and fixed by the alcohol.

Median Fistulæ and Thyroglossal Tract Operations.—Median fistulæ are much more certain and easy of removal. These, as noted above, are remnants of the thyroglossal duct or tract and occupy a median position in front of the trachea from the foramen cecum to the thyroid gland. Practically, we have no hope of curing these by injection of caustics to destroy their lining.

Here operations have given a rather larger percentage of cures than in lateral fistulæ, and are to be advised. The median scar, though long, is less conspicuous than the lateral, and the dissection far less tedious and dangerous. The previous use of methylene-blue injections to stain the tract and the careful identification of its whole course by

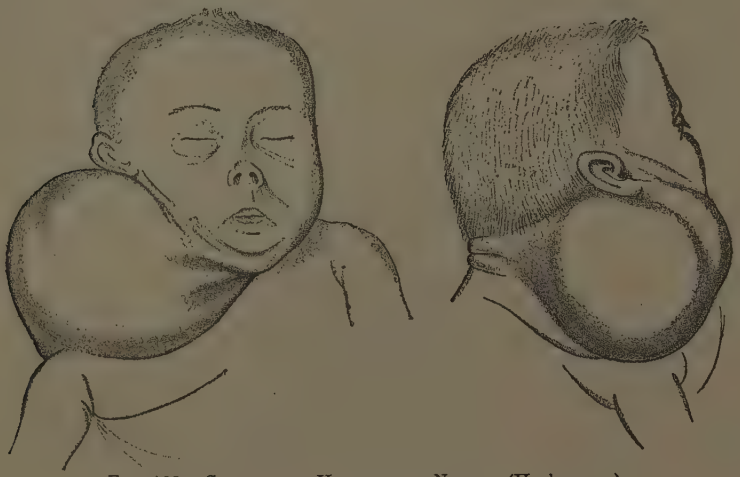


FIG. 166.—CONGENITAL HYGROMA OF NECK. (Hochenegg.)

flexible probes, which, if practicable, should be left *in situ* while operating, assist much in identifying the tract to be removed.

If attempts are made at extirpation without such aids it may be found that the course of the sinus is lost before its end is reached. The lining of the fistula does not differ enough in color or texture from ordinary cut tissue to enable us to rely upon the unaided eye or touch in removing it. Hence the great value of staining its interior and also filling its lumen with some hard substance. The aim of the operator should be to remove it entire and unopened, for any portion of its lining left in the neck will develop another fistula or a cyst.

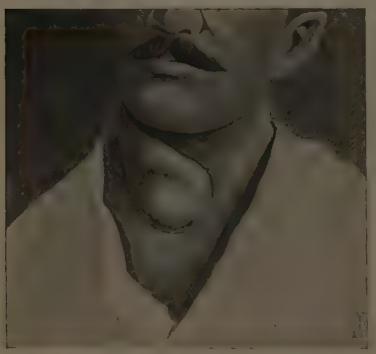


FIG. 167.—BRANCHIOGENETIC CYST. (Tuholske.)

Branchial Cysts and Dermoids.—Congenital sacs of the branchial clefts are to be classed with the fistulæ and require the same treatment. *Blood-cysts* have been noted in the region of the clefts, both with and without open connections with the vascular system.

Lymphatic cysts, or congenital hygroma of the neck, sometimes attain a large size, filling the compartments of the neck, distending the

skin, and even hanging pendulous upon the breast or shoulder. These are multilocular, as a rule, sometimes edematous and sometimes unilocular, in any case containing serum, usually not discolored. When very numerous cysts make up the mass it assumes the structure of a cavernous lymphangioma.

Treatment.—As these large cystic masses invade the intermuscular and other deep recesses of the neck their removal by operation is often impossible. Single cysts can be dissected out in some cases. Puncture and drainage do not, as a rule, effect much relief. Not a few cases have recovered spontaneously or by only local treatment, which was probably negative. These tumors show no malignancy.

WRY-NECK—TORTICOLLIS.

Wry-neck, torticollis, caput obstipum, caput distortum, a rotation deformity of the neck, is claimed by some specialists for the domain of orthopedic surgery under such titles as "cervical scoliosis" and "collum obstipum." Systematic writers continue to class this disease among the congenital abnormities of the neck, as is done in the present work.

General Considerations.—The equilibrium of the head upon the vertebral column is maintained by the coördinate action of all the cervical muscles. Disturbance of the balance between these muscles causes deviations more or less complex, simple flexion, torsion, or a combination of both, according to the group of muscles affected. Two forms of wry-neck, the spastic or fixed form and the clonic or intermittently spasmodic form, are generally recognized. These two types are of somewhat different origin and require different management. The term *caput obstipum* or *spastic torticollis* should be limited to one type of deformity, viz., that produced by myogenic contracture, beginning usually in the sternocleidomastoid muscle, and sooner or later involving other rotators, resulting in a peculiar nodding and rotating posture of the head. We should, therefore, exclude by this definition other closely similar deformities, such as those due to cicatrices of skin to vertebral caries or fracture, or those due to temperament, emotion, eye-strain, strabismus, occupation, or habit, sometimes called "physiological torticollis," "ocular torticollis," and the like. These deformities may look like but are not true wry-neck, which is associated with a muscular lesion or myositis, remote or present. The disease is mainly one of infancy and childhood, and more common in the male.

The usual division into congenital and acquired is not wholly accurate. Fewer cases are actually born with wry-neck than was formerly assumed, while many receive the injury at parturition, which starts the muscular disease or myogenic changes. Chaussier failed to find a single case actually born with the deformity in 25,000 births at the Maternité Hospital, Paris. Many of the cases reported as congenital torticollis were probably instances of vertebral caries, injury, or lack of development, rather than true wry-neck. Obstetric traumatisms, according to Dieffenbach, include contusions of the neck by forceps in delivery. Stromeyer considers the injury to be to the motor nerves.

St. Germain denies that the forceps blades ever press on the neck. Billroth and Volkmann consider the injury a rupture or partial rupture of the sternomastoid from hard traction on the engaged head. It is believed that this follows breech presentations.

Even in later life violent efforts have been known to cause rupture of the sternomastoid, myositis, retraction, and permanent wry-neck, as shown by cases reported by Amussat and von Eiselsberg. The classification into congenital and spasmodic wry-neck is still in use, however, and for convenience need not be disregarded. The clonic or spasmodic form usually has failed to improve under orthopedic management and, being so largely a neurotic derangement, has yielded to neurectomies, such as Keen's operation in congenital wry-neck.

Pathology.—As stated above, the primary changes are muscular and mainly in one muscle, the sternomastoid. A parenchymatous myositis takes its start usually from some traumatism, such as rupture

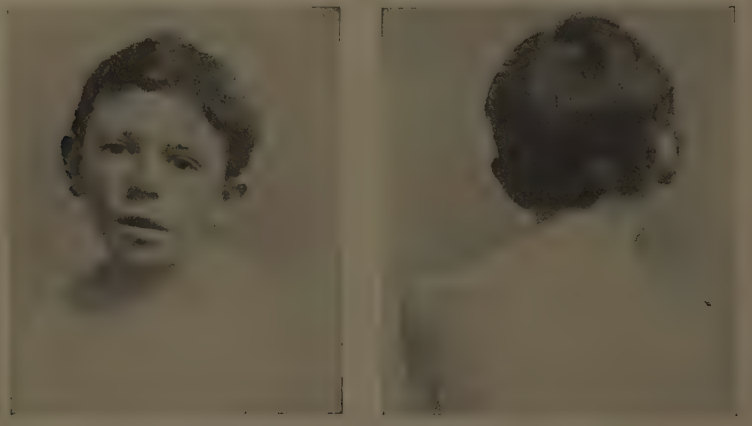


FIG. 168.—LEFT-SIDED TORTICOLLIS, FRONT AND BACK VIEW.
Note compensatory curves in dorsal region.

of fibers and hematoma. A localized inflammatory tumor has been noted in the course of the muscle. The sternomastoid is a muscle largely composed of connective-tissue and tendinous fibers among the muscular bundles. It is not surprising that irritation along its course should cause it to contract and shorten, just as when the tendo Achillis is irritated or injured we see contraction and resulting pes equinus. Secondary changes sooner or later develop. The physiologic rest of the inflamed muscle is secured by efforts of the surrounding groups to sustain and relax it. Hence all the neck rotators become indirectly involved, and may acquire later false contractions and adhesions, exactly as in other parts of the body. Even the vertebræ and intervertebral discs are said at last to become thinned on the concave side. Bouvier denies this, but no doubt exists that parts of the face and cranium (Fig. 169) are atrophic or have their growth restrained, so that when left uncorrected the features are found to be smaller on the side drawn down. The mandible, ear, and even superior

maxilla, orbit, and occipital bone may show this asymmetry in cases corrected too late in life. Asymmetry has even been noted in the scapulæ and shoulders. Peterson denies strenuously the rôle of sternomastoid rupture in causing wry-neck and Lorenz is of the same opinion. The rare instances of autopsies obtained on wry-neck cases (Robert, Guyon, Bouvier, etc.) seem to show a fibrous transformation of the muscle in most cases, with resulting induration and shortening. Volkmann found this sclerosis diffuse throughout the whole muscle, but in no cases followed by fatty degeneration. The right sternomastoid was more often affected—62 times in 87 cases. Guyon and Philips consider that the right side is more exposed to

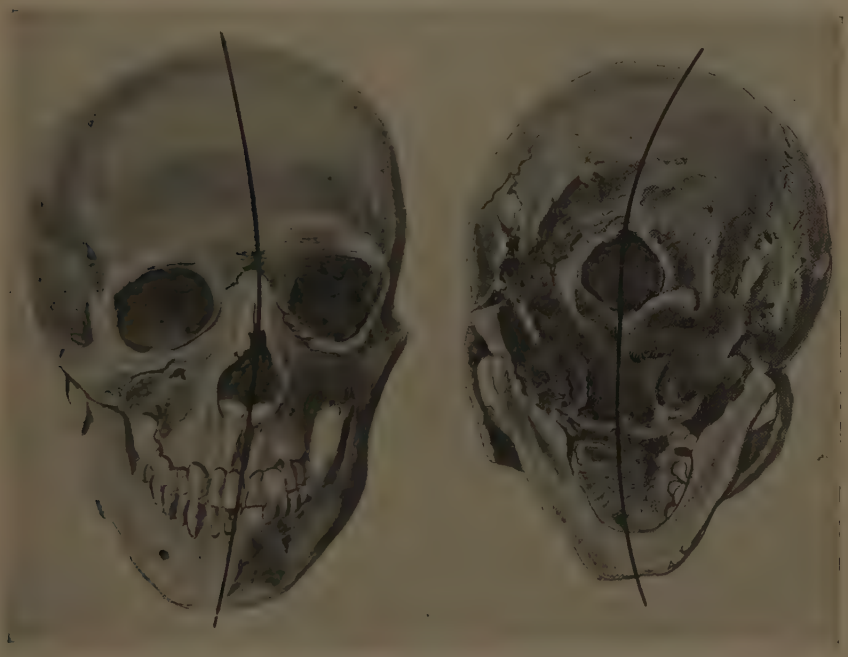


Fig. 169.—Front and Base of Skull in Torticollis. (Lorenz.)
Smaller bones on concave side of face and mandible.

traumatism at delivery, especially in the first position of the head. Other muscles, the trapezius, scaleni, splenius capitis, and deep rotators, possibly even the platysma, may play an important secondary part. The unilateral shortening of the muscles of the neck causes a scoliosis of the cervical spine, which in turn produces a compensatory scoliosis in the opposite direction of the dorsal spine, and even a lumbar scoliosis at times. In true congenital cases vertebral deformity may be marked. All the tissues which have lain contracted on the concave side of the deformity *in utero* become atrophied and shortened, exactly as they do in club-foot.

Treatment.—Zesas has well observed that the treatment of tor-

ticollis cannot be schematic, but must be individual. Success depends largely upon its being instituted early, before great alteration of structures has occurred. Hence operations or orthopedic appliances succeed more often in infancy than when used later, and in which the deformity is already old at birth.

Non-operative treatment is not to be condemned as useless, although it commonly fails to cure, just as it fails in club-foot. The value of orthopedic appliances and of manual correction is chiefly as an adjunct to operative treatment, where it is indispensable to success. A combination of operative and bloodless methods offers the only chance of success in cases of any severity.

FIG. 170.—MANUAL CORRECTION (REDRESSEMENT) OF WRY-NECK.

Operations on the Sternomastoid.—*Subcutaneous tenotomy*, as practised by Dupuytren, Dieffenbach, and Stromeyer, has had many advocates. It eliminates the dangers of sepsis and may sometimes be done as a minor operation without general anesthesia. In proportion as the contraction is limited to one muscle, the sternomastoid, tenotomy may be successful, but when other muscles and fasciæ are shortened it is ineffectual. Two methods of tenotomy are in common use, that by minute puncture and that by small open incision. The older puncture method is still a favorite with many good surgeons. Mikulicz urged slightly more open section, so that the edge of the muscle could be seen before cutting. As early as 1670 Roonhuysen had already practised this.

Technic.—The patient should be laid in the dorsal position, with a hard roll under the neck and the head drawn against the contracted muscle by an assistant. If doubt exists as to the ability to control the patient's movements, general anesthesia must be employed. The point chosen for dividing the muscle is near its lower insertion. The sternal head is usually found the more rigid, and this is first divided. The clavicular insertion next is cut, if needed. The surgical anatomy of these parts will be familiar to those who have done the cervical gland operation. As a rule the tendons stand out with the skin sunken between and around them, so that they can almost be pinched up through the skin. The structures to be avoided are the great vessels, subclavian or innominate, and carotids. The knife is entered generally at the inner border of the tense muscle, 1 or 2 cm. above its insertion. It can then be insinuated along the inner and posterior border, and

when in place carried forward and outward until the cut muscle gives way. The probe-pointed tenotome can be substituted after the first puncture, if the landmarks seem doubtful. In case of very fat subjects or when adhesions make the landmarks obscure, the open method is preferable. A very large number of such tenotomies have been done. Occasionally bleeding has been annoying, but, being venous, will always stop under compresses. The clavicular attachment can be divided in the same manner when the single tenotomy does not relieve the tension.

Open tenotomy, except for the slight skin incision, is no more severe and is a more scientific operation. At the same location a short incision, 3 to 6 cm., is made over the center of each tendon. The margins of the wound, on being retracted, expose its lateral border. It can then be seen, lifted up, and divided with perfect safety, and the skin united with a few sutures. The superiority of subcutaneous methods due to immunity from infection has disappeared with the advent of antiseptic surgery, so that many operators have discarded subcutaneous methods here, as in other parts of the body.

FIG. 171.—PLASTER BANDAGE FOR OVERCORRECTION AFTER OPERATION.

A certain amount of tearing of adhesions and associated fibers must now be done by overcorrecting with passive motion until no more resistance is felt to rotation, after which the head is held corrected by casts or braces for from three to six months. The head and shoulder cast is one of the most difficult to apply. A large number of turns must surround the head, neck, and shoulders. My own experience confirms the statements of Ridlon, Lorenz, and others, that no appliance can take the place of a strong plaster cast or ensure as good results.

Extirpation of the Sternomastoid.—Mikulicz found simple tenotomy inadequate to cure confirmed torticollis and resorted to extirpation of the lower two-thirds of that muscle. Kocher and Koenig confirm this and commend the operation. The loss of one or both sternomastoids is easily compensated by the other cervical muscles, as confirmed by Crile's method (see below).

Technic of Excision of the Sternomastoid.—An incision is made along the border of the muscle and the sternal and clavicular tendons undermined, lifted up, and divided. The lower end of the muscle is then lifted outside and carefully separated from the deep vessels to a point above the middle of the neck, so as to include the spinal accessory

nerve. Its lower half or two-thirds is then divided and the wound closed.

Operations upon the Posterior Muscles.—Many cases of confirmed wry-neck involve such general shortening of all the tissues of the neck that no one muscle is at fault, and require wide cutting of all the fascia, muscles, and tendons before the deformity can be corrected. The conditions are identical with those in inveterate club-foot, where every resisting band, regardless of its original function, has to be cut before correction can be obtained. This, followed by four or six months' retention in casts or suitable braces, offers the only hope of cure in bad cases.

In these confirmed cases the operator should open the skin freely and divide at once the most resisting band. Usually this will be the sternomastoid. The next band may be the edge of the trapezius and this must be cut transversely. Whatever bands now remain, whether fascial layers or the complexus or other muscles, are cut successively backward until the neck can rotate freely to a normal extent. The wound should now be closed and the head placed in an overcorrected position, where it is held by a cast or splint for at least four months. It will be noted that this somewhat resembles Keen's posterior nerve operation described below. Experienced operators are growing more and more favorable to radical wide dissections in inveterate wry-neck, as half measures yield so large a percentage of failures or relapses.

Operations upon the Nerves.—For spasmodic or purely muscular wry-neck, without secondary changes, neurectomies which paralyze certain muscles or groups have been extensively practised. The extirpation of the sternomastoid, above described, destroys the spinal accessory before it reaches the trapezius and incidentally paralyzes that muscle. Perhaps this is the chief merit of the method. Simple removal of that nerve in such a location as to paralyze both sternomastoid and trapezius is easily done by uncovering the upper end of the sternomastoid through a short incision along its posterior edge. The nerve enters its substance 1 or 2 cm. below the mastoid process. By pinching or probing the tissues its presence is made known from spasm below. When the muscle is pulled a little outward and forward the nerve is seen slightly inside and below its upper posterior edge. As much as possible of the nerve trunk should be resected to prevent regeneration. Southam and Hanson report successful cases of cure by merely stretching the nerve at this point.

Resection of the Posterior Nerves. Keen's Operation.—For the same reason that the posterior muscles need division in bad cases it seems proper to cause paralysis by nerve section in these groups rather than in the anterior muscles only. Keen, in 1890, published cases treated by extensive neurectomy. The nerves to be destroyed are those supplying the splenius capitis, rectus capitis posticus major, and obliquus inferior, viz., the muscular branches of the second and third cervical nerves and the suboccipital nerve from the first cervical.

Broadly speaking, cutting the posterior branches of the first, second, and third cervical nerves will accomplish this. The largest nerve involved being the occipitalis major, it is advised, first, to find and resect this, using it as a landmark to locate the others.

The steps of this operation, as practised by its inventors, are:

1. Incision in the skin, 6 to 10 cm., transversely, at 2 cm. below lobule of ear. 2. Transverse section through the trapezius muscle. 3. Location of the occipitalis major nerve after lifting the trapezius, where it leaves the complexus muscle. Its level is about 1 to 2 cm. below the level of the incision in the skin. 4. Transverse section of the complexus by slow dissection, following the nerve through its substance. This leads to its bifurcation from the second cervical. Excise a long piece from both nerves. 5. Search for and resection of the first cervical nerve. It lies deep in the wound and above the one just dissected. It is found by outlining the suboccipital triangle, bounded by the two oblique muscles and the rectus capitis posticus major. 6. Search for and resection of the external branch of the posterior division of the third cervical. It lies 2 to 3 cm. below the second cervical, already cut, and should be destroyed as far as the main trunk. This nerve supplies the splenius capitis. The cut muscles may be reunited, or if greater relaxation is sought (see above) of course they could be left separated and the forcible correction maintained by casts or braces. As this operation is done for clonic or spasmodic wry-neck only, the cutting of the muscles is merely an incident to the real object, which is the destruction of the motor nerve supply.

SUPPURATIVE PROCESSES IN THE NECK.

The development of a suppurative inflammation in the deep tissues of the neck always threatens life unless promptly relieved. Such a cellulitis is dangerous in proportion as it is deep seated and concealed, when it may make serious headway before it is detected. In this category are the cellular infections after incised and punctured wounds; fractures and wounds of the larynx and trachea; perforations of the esophagus; necrosis of the mandible, spine, or mastoid process, and infections of the parotid gland; suppuration of cysts, hygromas, or even, as Auger has shown, of veins thrombosed by adjacent inflammations. No part of the body is more subject to abscess formation from acute septic lymphadenitis than the neck. These glands have also a remarkable power of destroying and limiting infections, so that instead of causing phlegmons or cellulitis, they often directly prevent it, as is well shown by Peyrot, by themselves undergoing destruction. Chronic adenitis, even if suppurative, rarely causes burrowing in the cellular spaces, as adhesions and periadenitis wall in and circumscribe the pus.

Adenophlegmons and phlegmonous cellulitis are secondary to other lesions in the mouth, tonsils, teeth, throat, etc., and also occur in general septic diseases, scarlatina, erysipelas, typhoid, diabetes, small-pox, etc., by metastasis. All forms of pyogenic germs are to be met with, the streptococcus being, of course, the most virulent.

The topography of such abscess is determined by the atrium and locus of the infection, and by the lines of least resistance to the burrowing of the pus. The cellular spaces and compartments of the neck determine the direction of the pus for mechanical reasons. Walther divides the abscesses according to their route into—

I. Abscesses of the posterior region of the neck.
II. Abscesses of the lateral and anterior regions.
    A. Superficial.
    B. Deep.
        1. Above the hyoid: Submental, mandibular, Ludwig's angina, etc.
        2. Below the hyoid: Tracheal, submastoid, Dupuytren's phlegmon, deep cervical, diffuse cellulitis.

It does not seem so important to preserve a schematic arrangement of locations as to emphasize the dangers attending these cases and to warn against delays in treating them. The abscesses of the posterior region do form a somewhat distinct group of cases. Large phlegmonous and sloughing cavities, beginning as furuncles and carbuncles, occasionally present on the back of the neck. Part of these are in diabetics and are forms of diabetic gangrene. Others seem to begin in the follicles of the skin in healthy individuals and produce large sloughing cavities, laying bare the aponeurosis. They are, as a rule, not markedly painful and cause less constitutional reaction than their size might indicate. Abscesses here seldom lead to burrowing and distant extension, but, like all carbuncles about the head and neck, may be followed by metastatic cerebral and meningeal suppuration.

In the lateral and anterior regions of the neck superficial abscesses are harmless and easily relieved by incision. Most such cases are from superficial lymphatics or from furuncles and carbuncles.

It is the deep abscesses of the sides and front of the neck which are most dangerous and important. Once inside the deep fascia, the pus finds free cellular spaces into which it can burrow or gravitate. The favorite locations for such burrowing are:

1. *Thyrohyoidean Space and Around the Trachea.*—Pus accumulating around the larynx extends between the epiglottis and the thyrohyoid membrane, where certain lymphatics lie. A fluctuating tumor appears around the thyroid cartilage, causing symptoms of compression and suffocation, like edema of the larynx. A little lower down, similar infections surrounding the trachea and cricoid occur, with much the same class of symptoms. Many of these cases receive their infection from lesions inside the larynx.

2. *Beneath the Sternomastoid.*—Most large and deep abscesses of the neck are in this location. As they fill the compartment containing the great vessels of the neck as well as the main chains of lymphatics, free communication exists with two important cavities, the subclavicular space leading to the axilla and the anterior mediastinum. Into either of these spaces the pus may flow without much resistance, so that large additional abscesses greatly endangering life may rapidly follow neg-

lected suppuration. The usual course is to a fatal result when the chest has been invaded, making it vitally important not to delay operations in such cases.

Retropharyngeal abscesses, lying between the vertebræ and pharynx or esophagus, are due more often to Pott's disease or esophageal injuries or diseases, and are more fully described in another chapter. These, like the substernomastoid phlegmons, are prone to invade the chest and infect the pleura, pericardium, or bronchi. It is not uncommon for such collections to rupture and discharge through a bronchus. Fragments of necrosed vertebræ are sometimes expectorated from such abscesses in cervical Pott's disease.

Diagnosis.—The diagnosis of cellulitis and phlegmon is not difficult. Certain symptoms are constantly present, pointing to septic trouble: high temperature, pain, rigidity, and edema of skin or muscles in the regions above noted. A high leukocyte count develops early. Sometimes fluctuation is easily made out, but often at first only brawny induration and redness can be found. As swelling and induration increase, symptoms due to compression often appear—dyspnea, dysphagia, and even venous obstruction. The larynx and trachea may be distorted or flattened, so as to require tracheotomy, and an extension into the chest may bring on still further respiratory trouble, together with severe or fatal collapse and toxemia. Adenitis and periadenitis and thrombosis of large veins often add their dangers. Dysphagia, aphonia, and severe nerve symptoms are not uncommon. Pupillary and vasomotor disturbances point to pressure on the cervical sympathetic. These symptoms are more pronounced in severe infections, such as occur in scarlatinal and erysipelatous cases. Gangrene may occur in such cases, especially in diabetic or alcoholic subjects, as in phlegmonous cellulitis in other locations. Eruption of the pus into neighboring cavities, the trachea or larynx, pericardium or pleura, with pulmonary edema and a few cases of pulmonary embolism, have been reported. Emphysema of the tissues of the neck or chest sometimes follows such perforations. Perforation of vessels causing severe hemorrhages has been reported. Monod collected 38 such accidents, of which 28 were into the artery. Henrot describes a case of cellulitis followed by rupture into the spinal canal, with speedy death.

Treatment.—Little emphasis should be put upon palliative treatment of these affections, as they have imaginary rather than real utility, and may cause dangerous delays. The one imperative need is to give exit to the confined pus. However small in amount, its focus needs immediate removal. It may be assumed that any acute, deep, hard swelling in the neck, with general signs of sepsis, is an abscess, and needs early exploration. Edema, redness, and tenderness, even without fluctuation, require early incision. Should only blood or serum, and no pus, be found, the operation still may be curative by forestalling suppuration. Very few or no such swellings will be met which are not true pyogenic infections.

No anatomic directions can be laid down that will apply to all

operations. The fact that we must lay open cavities among the great vessels, nerves, air-passages, etc., makes free incision difficult. At the same time our knowledge of these tissues *in vivo* is so much increased by experience in gland, nerve, and vessel surgery that we have no real difficulty in gaining access to any compartment of the deep fascia from several directions. Instead of bold incisions, we resort to slower dissection by Kocher director, Mayo's scissors, and Crile's appliances. No case of phlegmon is so deep or indurated that by slow anatomic dissection we cannot lay it open and explore its interior. From our knowledge gained in the other operations on the neck we have, of course, more than one route to reach the deeper parts. We can choose the route behind the sternomastoid or in front of it, or through it, or by

FIG. 172.—THE AUTHOR'S RADICAL OPERATION FOR DEEP CELLULITIS. Tamponade of substernomastoid and submaxillary regions. Additional incision and rubber drain in case of burrowing.

even extirpating it, as circumstances compel. When free access has been gained to the spaces in the neck and their purulent contents have been evacuated, it is well to search for pockets or branches into which collateral drains can be inserted. If the abscess began above the hyoid bone or near the jaw, its lower end may be near the sternum or under the clavicle. Not only should one extremity be provided with an outlet, but large free openings should be made at both ends and free use of tubes or through-and-through drains inserted. Care must be taken not to leave hard tubes or gauze tampons too long in contact with large vessels, as they might cause ulceration of their walls and hemorrhage. In case of thrombosis or ulceration having already caused hemorrhages from large vessels, tamponade by iodoform

gauze and local use of adrenalin may give temporary respite, but such accidents usually call for ligation of the vessels at another point, usually to secure permanent safety.

CERVICAL RIBS.

The congenital anomaly, supernumerary ribs, occurs usually in the cervical, but has been observed in the lumbar region. It is a deformity seldom discovered early and often is overlooked or causes no symptoms throughout life. Hunauld described this anomaly in 1742. Gruber, in 1849, reported other cases. Willshire and Huntemueller detected the deformity first in the living. With the advent of radiography the diagnosis of this condition was rendered certain and easy, so that now it is known to be common.

More females than males are affected.

In Keen's compilation of 43 cases operated upon there were:

Females	32
Males	11
Total	43

We are reminded by Thomas and Cushing of a controversy started in Sir Thomas Browne's "*Pseudoxia Epidemica or Commentaries on Vulgar Errors*," London, 1650, on the subject of Eve's and Adam's supernumerary ribs, as represented in modern man by such rudimentary organs.

The affection is bilateral in 75 per cent. of cases. As a rule the false rib springs from the seventh cervical vertebra, but cases are reported by Beck, Hauswirth, and Williams in which they grew from the sixth cervical. They are more or less completely developed in different cases, giving rise to four principal types:

1. Slight projection not beyond transverse process. 2. Slight projection into muscles. 3. Well-developed bony rib reaching down to first rib. 4. Complete additional rib united at the end to the first rib.

L. Barker states that they may form a complete ring to the sternum. They may have articulations or may be ankylosed to the spine, sometimes with exostoses and false positions, forming a bony tumor. Halbertsma believed that if more than 5 cm. long, the rib displaced the subclavian artery as well as the lower cervical nerves. The artery is given a higher arch and a sharper curve, as the chest is practically lengthened by one rib. This carries the arch of the subclavian vessels above the clavicle into the soft parts of the neck, where it is in danger of being injured. The vein is not displaced. The scaleni muscles are often attached to the cervical rib instead of the first. The pleura is elevated and may rise above the clavicle, so that it, like the vessels, may be torn in accident or operations if the presence of the anomaly is unknown. Less than 10 per cent. of cervical ribs ever give symptoms or are discovered during life. The local sign of their presence is a visible or palpable tumor above the clavicle, which can sometimes be followed to the spine. A certain degree of scoliosis is often present.

The high position of the artery has been mistaken for an aneurysm. Sometimes aneurysm actually does exist as a result of the bony pressure. Abnormal pulsations above the clavicle point strongly to cervical rib, especially if there be tender nerve trunks in addition.

The most frequent results of the deformity are the nerve phenomena referred to the hand and arm, due to pressure on the roots of the brachial plexus. This may amount to a true neuritis. Anesthesia or prickling of the extremity and neuralgic pains are frequent; also loss of motor power. The cervical sympathetic may show pressure symptoms, also the recurrent laryngeal, producing flushing, ocular disturbance, hoarseness, and dysphagia.

Interference with the subclavian vessels is, next to nerve disturbance, the most common symptom. The artery may be entirely obstructed and its lumen obliterated. The pulse is then absent in

Fig. 173.—Cervical Rib on Left Side.

the wrist and the limb very anemic. There have been reported cases in which even the subclavian artery and all branches below it were thrombosed. Collateral circulation must then supply the limb, and this is not invariably sufficient, so that dry gangrene from anemia attacks the fingers. This rarely goes above the finger-tips.

Venous obstruction is very rare, much less common. In very few cases is edema present.

Trophic changes in the arm, atrophy, and loss of power correspond in degree to the amount of anesthesia. As a rule, cervical ribs cause no trouble in early life. Certain injuries may bring on the symptoms. Tillmanns, Planet, and Beck report such results from falls and blows. Certain occupations or habits, carrying knapsacks, the recoil of a gun, wearing tight collars, may produce the first signs of the trouble. The diagnosis after such symptoms have been noted is easily verified by the *x*-ray.

Treatment.—The condition may not require treatment other than rest and posture. This is true of most cases of cervical rib. The minority, which show signs of gangrene or paralysis, may require operation for removing the rib. The symptoms are often unilateral and only the rib on the affected side needs removal.

The operation has been uniformly successful. Two forms of skin incision have been utilized, a vertical behind the sternomastoid, and a horizontal above the clavicle. These two forms can be combined if a large space is needed. The thoracic duct and phrenic nerve are to be avoided, as well as the pleura and subclavian. The operation consists in drawing aside the great vessels sufficiently to get at and resect the false rib with cutting forceps. It is necessary to divide its attachments both to the first rib and to the spine. The lower cervical nerves must be held aside and protected, and every effort made to avoid opening the pleura, which is sometimes attached to the rib. Should this accident occur it is not, as a rule, serious. The aim should be to remove the rib with its periosteum to prevent regeneration, and this makes it less easy to push aside the pleura or adherent vessels. Recurrence of the trouble has been reported from leaving the periosteum and also from leaving sharp bony prominences instead of rounding them off. The opposite ends of the rib can be best divided by pulling the vessels first to one side and then the other. The large nerve trunks must be handled with gentleness when stripped away from the rib. Several cases of temporary paralysis from want of care in this step are reported. Like most wounds of the neck, these incisions heal rapidly if slight provision for drainage is made, when there is persistent bloody discharge.

LIGNEOUS ABSCESS OF THE NECK (HOLZPHLEGMONE).

Under the name "*phlegmone ligneuse*" Reclus described a peculiar inflammatory process occurring in the neck, characterized by a slow course and a wood-like hardening of the tissues. The cause of this interesting disease, according to Moreau, is a certain attenuated infection, not quite able to break down the tissues, but causing chronic induration without much free pus. Sick reported a case apparently following a mastoid abscess. Schmincke has recently attempted, from the findings of one case, to make out a resemblance to a neoplasm and characterizes the disease as "cancer-like" (cancroid). Merkel, continuing the histologic study, found only lymphocyte and leukocyte infiltration, and denied the validity of the cancerous theory, citing the well-known fact that most of these cases run a benign course. This form of phlegmon has shown many different microörganisms in the cases so far examined. In 5 cases recently reported by Fichter numerous and various pus germs were present.

The earliest **symptom** of the disease is generally a swelling of the submaxillary and retro-auricular lymph-nodes on one side, rapidly followed by periglandular inflammation, without much involvement of the skin at first. The edges of the mass have often sharp margins, the

whole assuming later an extraordinary hardness very unlike most inflammations, there being no pain, tenderness, or fever. Little or no suppuration or softening occurs, and the disease remains essentially chronic and stationary for long periods.

The differential diagnosis is mainly from malignant growths and actinomycosis.

Prognosis and Treatment.—Most of the reported cases have finally recovered. The long-continued inflammatory tumor disappears, usually by resolution, but only after months of delay. Treatment has little or no effect, so far as we know, in bringing this about. External applications, Bier treatment, incision, puncture, or efforts at removal of glands or other tissue by dissection, are alike unavailing or dangerous. It is not even necessary to use fomentations, as no pain is present, and they do not seem to hasten the softening. The disease does not, as a rule, threaten life by invading the deepest layers or the chest cavity. During its course the general health suffers less than in acute phlegmon, nor have dyspnea, dysphagia, or nerve disturbances been serious or alarming.

DISEASES OF THE GLANDS AND LYMPH-VESSELS OF THE NECK.

The cervical glands probably stand at the gateway of more lines of invasion than those in any other part of the body, so that we associate glandular disease instinctively with the neck, such is its predilection for that part. We make no fundamental error in thus associating glandular troubles with the neck, for not only are they most common there, but the neck is the embryonal center where glands first appear in development.

The lymphatics were known to the ancients, as Herophilus and Galen. Eustachius, in the sixteenth century, described the thoracic duct. Asseli, a little later, found the lymph-vessels in animals. Steno found the right thoracic duct. The valves were found in the seventeenth century by Blosius, Ruysch, Bartholin, and others. Bichat added much to our topographic knowledge. Finally, Sappey published his elaborate atlas in 1876, which has never been equaled, and embodied laborious researches extending over thirty years. Histologic investigations of their anatomy were not attempted until the time of Virchow and Recklinghausen.

Sappey's method of injection by metallic mercury and Gerota's by Prussian blue have added greatly to our knowledge in recent years. Embryonic lymphatics are less easy of study. They cannot be stained by silver salts, but are fairly differentiated by osmic acid injections of the fat spaces.

Topography of the Cervical Lymphatics.—Lymphatic territories exist in the neck as in all parts of the body. The lymph-vessels of certain tracts drain into certain larger ducts, which thus form pedicles or collecting trunks for different clusters of glands. It is important to recognize these anatomic groupings in studying the infections and metastases of cervical glands.

Poirier makes a schematic arrangement of the neck glands into (1) a collar or circle around the top of the neck from which hangs (2) a vertical chain on each side under the sternomastoid to the chest. This is in turn flanked by several accessory chains.

The collar or circle itself is formed by (1) the occipital group; (2) the mastoid; (3) the parotid and subparotid; (4) the submaxillary; (5) the submental; (6) the retropharyngeal.

1. The *occipital glands* receive infections from the hairy scalp and discharge into the upper deep descending chain (under the sternomastoid).

2. The *mastoid group* or retro-auricular glands terminate in the same direction after draining the auricle, meatus, and part of the adjacent scalp, and discharge thence into the substernomastoid chain.

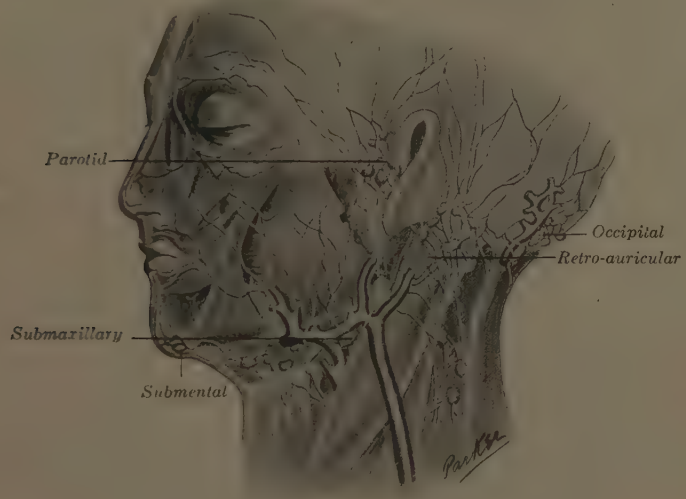


FIG. 174.—CIRCLE OR "COLLAR" OF THE UPPER NECK GLANDS.

3. The *parotid glands* are of great interest, because it is now proved that they lie both adjacent to and within the substance of the parotid salivary gland. Hence their important rôle in infections and tumors of that organ. They drain the meatus, tympanum, part of the cheek and the temporal region, and empty into the deep jugular and substernomastoid chain. They have also an inner chain, called the subparotid glands, deeply placed in the space between the pharynx and parotid. These drain the nasal fossæ, the lateral pharynx, and the Eustachian tube. At times they give rise to deep pharyngeal abscesses.

4. The *submaxillary glands* form a chain along the lower jaw and are of great surgical importance, because so often involved in tuberculous disease, and by metastases from cancers of the mouth and tongue. They drain the nose, cheek, gums, lateral and anterior parts of tongue, and lips, except the center of the lower lip. Their efferent ducts

lead to the bifurcation of the carotids and so to the deep descending chain.

It is of interest to consider whether, like the parotid group, these glands enter the substance of the submaxillary salivary gland. The best anatomists hold that they do not, although Rawitz found that they apparently did do so in certain monkeys. One lymph-gland usually lies so closely adherent to the salivary submaxillary that it is safer and easier in doubtful cases to remove both rather than to risk wounding

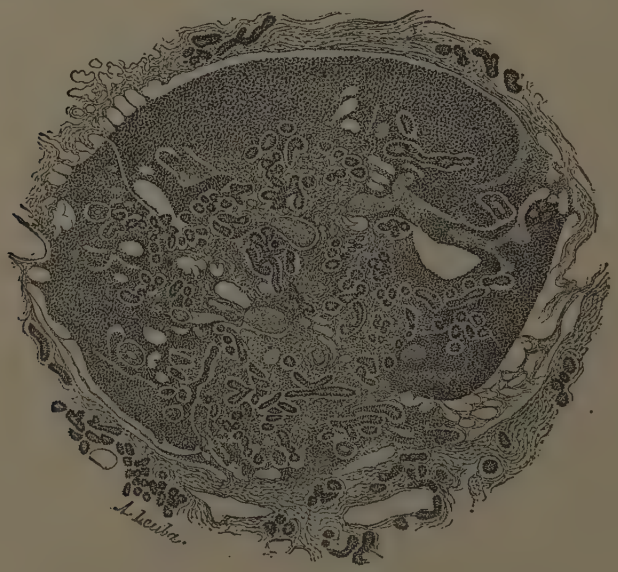


FIG. 175.—SECTION OF A PAROTID GLAND (FETUS OF TWENTY-ONE CENTIMETERS). (Neisse.)
In this figure may be seen the invasion of the lymphatic gland by several glandular acini which have penetrated into the gland as far as the hilum and show a tendency to reach its cortical substance. (Poirier and Cuneo.)

its duct or afferent artery. This is particularly true of cancerous glands.

5. The *submental glands*, directly beneath the symphysis, are small and few in number. They drain the middle portion of the lower lip and sometimes are involved alone from carcinomata at this point; also the skin on the chin, the middle of the mandible and the lower gum, and tip of tongue. They discharge a few vessels into the subhyoid space.

6. The *retropharyngeal glands* lie behind the pharynx, next to the vertebræ. They drain the vault of the pharynx, nasal fossæ, middle ear, and Eustachian tube, and discharge by deep-lying ducts which reach the deep chains by passing around and mostly behind the great vessels. The chief importance of the group lies in their relation to retropharyngeal abscesses.

The Descending or Substernomastoid Group.—From the above "collar" classification we have seen that certain areas of the head

FIG. 176.—RETROPHARYNGEAL LYMPH-NODES.

and face are drained by certain definite groups of glands. This is of great use to us in determining the atrium of an infection, and the

FIG. 177.—SUBSTERNOMASTOID OR DESCENDING DEEP GROUP, WITH ITS CONNECTIONS.

possibility of metastases. It is not to be forgotten that these groups overlap and anastomose with each other to some extent, so that their

limits are often ill defined. The collecting trunks discharge through one group into another, so that successive glandular areas are traversed by the ducts from above downward. Thus all the cervical circle or collar discharges into the descending chain, which occupies the track of the great vessels. These are the largest and most important glandular masses of the neck and, like similar groups in all parts of the body,

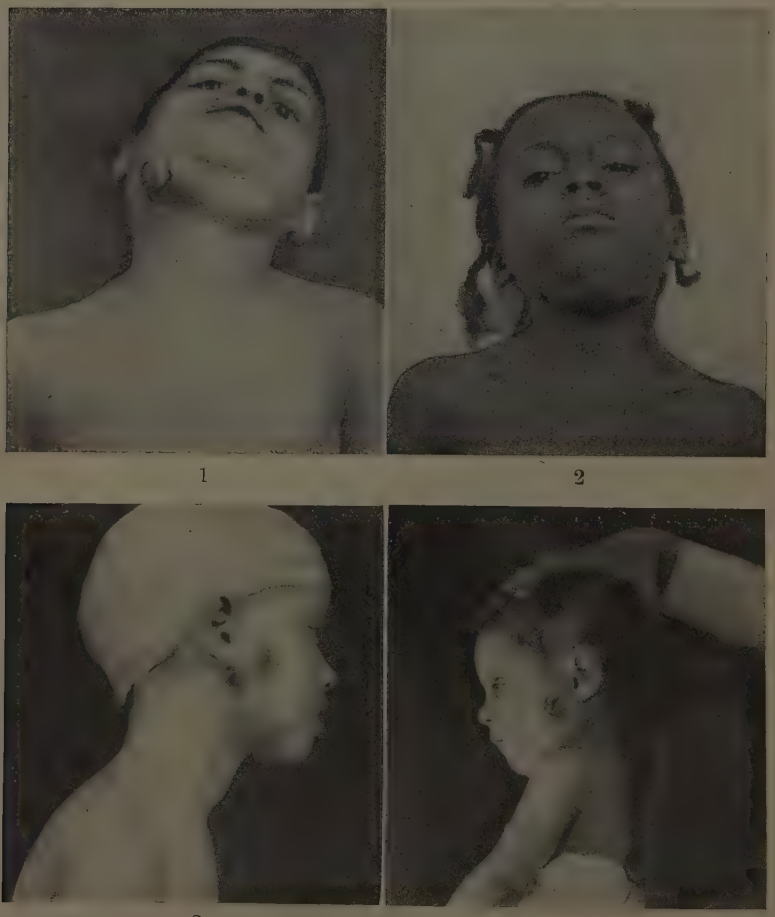


FIG. 178.—TUBERCULOUS LYMPH-NODES. (Dowd.)
1, Submaxillary; 2, submental; 3 and 4, parotid group.

their anatomic distribution follows that of the veins. We may particularly emphasize this in the neck, since the dissection of these brings us to the greatest of all lymph-ducts—the thoracic duct—and reminds us of what Ranvier says of the lymphatic system as a whole, that it is, as it were, one immense gland which pours its secretion—lymph—into the veins. The descending deep cervical gland mass follows the internal jugular vein from near the mastoid process to the

subclavian. This chain drains all the upper group and in addition the pharynx, ear, face, neck, lips, mouth, tongue, etc., by independent ducts. The extension of this group outward forms the supraclavicular group filling the triangular mass of fat bounded by the trapezius, sternomastoid, and clavicle. They drain the scalp and neck, surfaces of the upper arm, axilla, and even breast. Hence their involvement in certain mammary and axillary tumors.

Acute adenitis of the neck follows various infections of the teeth, mouth, gums, nares, tonsils, etc.; also the exanthematous fevers, as diphtheria and scarlatina. It is usually bilateral and disappears quickly with recovery.

Ulcerative diseases, chancres, lupus, etc., about the face quickly cause multiple glandular swellings about the neck which may end by resolution or by abscess formation.

Chronic hyperplastic enlargement of the cervical lymph-nodes is almost always tuberculous. The atrium of infection is usually in a carious tooth, a diseased tonsil, or some lesion about the nares or larynx, adenoids, tonsillar infections, and the like. The course is usually very chronic and ends sometimes in resolution and disappearance, more often in caseation, abscess formation, and multiple sinuses about the neck. These cold abscesses seldom cause dangerous phlegmons or much reaction, but refuse to heal and continue to break in various places, forming undermined, violet-colored patches of skin surrounding the fistulæ, until unsightly scars are left everywhere. The enlargements which do not suppurate form tumors at times of great size, filling the submaxillary and submastoid spaces and side of neck, until the head may be rotated or bent over. In most cases the tumors are smaller, from the size of a hazel-nut to that of a hen's egg. They are painless and hard, sometimes movable and sometimes fixed by exudate and adhesions. Their centers are caseated and necrotic long before they develop abscesses. There is usually little or no fever unless general tuberculosis be present.

The **differential diagnosis** has to be made from malignant diseases, lymphosarcoma, carcinoma, pseudoleukemia, and various acute infections.

Treatment.—The treatment of tuberculous adenitis should not be operative in all instances. Cases in which recession begins may recover under hygienic or sanitarium treatment. It is doubtful if iodin or external applications of any sort, or even the Bier treatment, influences the course perceptibly. All known methods of combating general tuberculosis should be tried.

Operative treatment offers two advantages in persistent cases—the prevention of sinuses and scarring and the removal of tuberculous disease from the system. It is certain that some patients after these operations are relieved of all symptoms of tuberculosis and gain rapidly in health, but a considerable percentage fail to obtain a complete cure and succumb ultimately to pulmonary or other tuberculoses. Demmé found in the reports of the Berne Hospital that 29 per cent. out of 692

cases observed died later of tuberculosis of the lungs, intestine, meninges, or kidneys.

Operation for removal of the glands needs to be radical. Partial removal of the chains involved—*i. e.*, taking out the larger lymph-nodes only—is followed by almost immediate recurrence. The others of the chain become enlarged in some cases almost before the wound is united. This may be repeated several times unless the operation is planned so as to take out every gland of the whole chain, whether enlarged or not. Even then it is not uncommon for distant chains, as on the opposite side, shortly to become enlarged.

FIG. 179.—INCISIONS FOR RADICAL OPERATION ON TUBERCULOUS GLANDS.
A and *B C*, Dowd's two incisions which give access to large part of neck. *D E*, Retrosternomastoid incision. *X*, Point of exit of spinal accessory nerve from edge of sternomastoid.

It should be a rule, therefore, to remove them radically or not at all. The radical operation should not be done on cases with cellulitis and open sinuses. These should first be cureted, injected, and healed. The mechanical difficulties of dissecting out glands from the indurated and inflamed tissues are very great, as are also the dangers of wound infection.

Technic of the Radical Operation for Tuberculous Glands of the Neck.—*Incision.*—As the aim of the operation is the radical removal of the whole mass from one side of the neck, an incision has usually been made from the mastoid process to the clavicle, along the posterior border of the sternomastoid. This may be called the anatomic incision, as it follows the main trunk of the venous system

of the neck, the internal jugular, along which the glands cluster. Mayo advises a similar incision, somewhat S-shaped, by curving its lower end backward and its upper end forward. An objection to these incisions is that they often leave long, unsightly scars above the collar line. Accessory incisions must also be made to remove the submaxillary or parotid lymph-nodes.

Dowd advocates less disfiguring incisions by following the circular furrows of the neck, which leave an almost invisible scar, as advocated by Kocher for goiter operations. The transverse incisions can be made at two levels, one for the removal of the upper circle of glands parallel to the lower jaw, and one 4 cm. below it, extending from the line of the meatus, or even the hair line, forward toward the chin. For more radical operations he adds another, extending from the hair line, near

FIG. 180.—EXTENSIVE TUBERCULOUS INVOLVEMENT OF THE SUBMASTOID, SUBMAXILLARY, AND DESCENDING CHAINS. (Dowd.)

the occiput, obliquely toward the clavicle, and curving forward, so as to encircle the neck a few centimeters above the clavicle.

Whatever the primary incision the skin and platysma are reflected, uncovering the sternomastoid, and the deep fascia is divided. Fenger advised cutting the clavicular insertion of the sternomastoid and placing a ligature temporarily around the internal jugular to prevent air embolism in case of accidental wounding. Most operators now find it unnecessary to divide the muscle, and secure distention and absence of suction in the vein by inserting a pledget of gauze against its lower end. This causes it to stand out and cease respiratory movement quite as effectively as the ligature.

It will be observed that this operation has some resemblance to that of Crile, given below, for malignant glands, but is much less radical.

The aim of the operation is the radical removal of the gland chain with its enclosing fat in one piece from the clavicle upward. As above stated, this operation is difficult or impossible in the presence of pus or much periadenitis. In clean cases the glands are readily stripped by blunt dissection from the subclavian vein and internal jugular, and the triangular space behind toward the trapezius.

Especial care must be exercised not to divide the thoracic duct. When the lower end of the mass is freed, it can be separated upward along the vein which it closely follows. The Kocher director, intended for goiter operations, and the Mayo dissecting scissors are useful instruments at this stage. At about the middle of the incision the upward dissection is stopped by the crossing of the spinal accessory nerve from the sternomastoid to the trapezius. This branch should be isolated and saved whenever possible. Pinching or probing it will cause a spasm of the trapezius. After it has been located it must be left with a bridge of tissue. The gland chain must now be divided and the dissection continued upward or else the lower mass may be left attached and drawn under the obstruction. The upper half of the dissection is deeper under the muscle and more difficult. Glands of the submastoid group are prone to lie deeply buried under the fibrous insertion of the muscle and hard to free. The chain also follows the vessels forward under the sternomastoid, where the adhesions are firm and the dissection is done out of sight. Both sides of the muscle should be cleared and its belly can then be lifted enough to get good access to the bifurcation of the vessels and beginning of the submaxillary chain. The largest glands are often found at this point. It is seldom necessary to cut the muscle, either vertically or transversely, if both its borders are freely undermined, so that it can be lifted and drawn from side to side.

FIG. 181.—MAYO'S DISSECTING SCISSORS. The closed blades are thrust into the tissues and then opened, acting as blunt dissectors.

Circular incisions, as a rule, are needed to remove the submaxillary and submental glands. Some operators have avoided this by very extensively undermining the flaps of skin and drawing them forward, thereby omitting additional external incisions. In the neighborhood of the submaxillary salivary gland several lymph-nodes sometimes are found so near its capsule as to make their removal difficult, except by taking it away also. There is no serious objection

to doing this, but except in malignant disease it can be avoided by careful dissection. Especial care is to be taken not to injure the efferent artery and duct. In the parotid gland lymph-nodes often penetrate and become imbedded, as mentioned below.

The wounds, even after extensive removal of the glands, heal rapidly if temporary drainage is made. If care is used not to get scarring from the stitches an almost invisible linear cicatrix results. Longitudinal subcuticular sutures, either of catgut or unabsorbable material, give good cosmetic results.

Actinomycosis of the Neck.—Tumor-like masses appear in the neck in actinomycosis which may simulate carcinoma in their slow progression. The growth is slower than true cancer and shows a greater tendency to form sinuses. Still massive thickening exists, and it may not be possible to verify the diagnosis except by the microscope.

The real test—finding the ray fungus in the discharges or tissue—can be made conclusively in all cases sooner or later. It is to be noted that true metastases occur in this and some other mycoses, causing errors in diagnosis unless critical care is used. (See Vol. I., p. 516.)

Disseminated blastomycosis runs a rapidly malignant course in many subjects. An unusual series of 5 such cases appeared in the Chicago clinics of the past five years, reported by Walker, Montgomery, Bassoe, Pusey, and Ormsby. In several of these the vertebræ, lungs, intestines, and thyroid became involved in metastatic growths before death. The microörganism of this disease is difficult to identify. Its atrium is usually a lesion of the skin, as in 6 of 13 cases reported by Ophüls, who classifies the affection under the term "coccidioidal granuloma." (See Vol. II., p. 648.)

Other affections occurring in the neck are *fibroma molluscum*, mentioned by Schnitzler, who also reports the occurrence of *pigmental nerve nævus* and the commoner *pampiniform neuroma*. In rare instances a peculiar hypertrophic mass is met on the skin of the neck, known to dermatologists or pathologists as *elephantiasis neuromatosa congenita*. These affections are usually not amenable to surgical interference.

THE CAROTID BODY OR GLAND.

The carotid gland or ganglion intercaroticum is a small body attached to the wall of the carotid artery, usually at its bifurcation. In size it varies from that of a grain of rice to that of a grain of corn. Funke found its location to vary several inches up or down the vessel, and noted its frequent absence in dissections.

The body was first described by Haller, in 1743, and the microscopic anatomy by Dushka, in 1862. The most characteristic feature of the minute anatomy is the so-called "cell-ball," which is everywhere seen lying in small capsules formed by the fibrous septa. It contains many nerve fibers and some ganglion cells, leading to the supposition that it belongs structurally to the sympathetic nerve system.

Malignant Growths.—The liability of this gland to become the seat of malignant growth was noted in 1880 by Riegner, who removed such a tumor by operation. Maydl, Dittel, Gersuny, Malmosky, Reclus, and others later reported cases in Europe, as have Scudder, Hearn, Keen, and Da Costa in America.

Usually these growths have been found malignant, of the type called *perithelioma*. Occasionally they were pronounced doubtful or endothelioma. When removed late or incompletely, recurrences are the rule. The clinical diagnosis is not always easy. Carotid tumors have been mistaken frequently for lymph-nodes or lymphosarcoma. The tumor commonly lies over the forks of the carotid, extending from the jaw to the hyoid bone. Several of the cases reported were the size of a hen's egg; others much smaller. The mass often pulsates or is so lifted by the carotid pulse as to give a strong impulse. As in exophthalmic goiter, there is often vasomotor disturbance, irregular flushing of the head, neck, and face, and some exophthalmos.

The pathologic diagnosis has usually been made only after removal. Reclus, in 1903, diagnosed one case before operation, the pathologic diagnosis after operation being reported as "perithelioma of the retrocarotid corpuscle."

The influence of age and other predisposing or exciting causes is as little understood in this as in other tumors. Heinleth's theory is that the carotid gland ceases growth at puberty, and that thereafter, if growth persists, it constitutes a tumor. One of the reported cases was eighteen; 9 were under thirty-five, and 1 was sixty years old. Only 3 were past forty.

Treatment.—It would seem that *very early* removal should be advised in every case of carotid tumor. All cases are not seen in this favorable stage, however, and very formidable difficulties are met with when the extirpation is attempted in advanced cases, from the fact that the three carotids—common, external, and internal—usually require ligation. This step alone, according to Barcull, causes a mortality of over 25 per cent. Many who do not die have serious brain complications or nerve disturbances. Da Costa's case had complete hemiplegia. In Keen's, Da Costa's, and all but 3 of those in Funke's collected cases ligation was performed. Various nerves have also been injured, the pneumogastric, sympathetic, hypoglossal, and recurrent laryngeal, so that sequelæ in the form of paralysis of vocal cords, aphasia, pulmonary congestion, secondary hemorrhages, hemiplegia, aphonia, and sympathetic nerve symptoms, flushing, mydriasis, etc. have been unpleasantly frequent.

Reclus advised waiting for dangerous symptoms before operating. This is seconded by Da Costa. It can only be justified by the belief that some of these tumors are benign, which is not generally believed. Other authorities advise early operation. Of the 17 cases above mentioned, 7 are reported cured without permanent complication, and several as cured, but left with aphonia or some paretic condition. The operation is essentially like that for the removal of deep submaxillary

lymph-nodes, especially those which lie at the forks of the carotid. Possibly the artery clamp of Crile would enable us at times to dispense with ligation. Probably the radical extirpation of the muscles, veins, and glands practised by him would not be adapted to this class of tumors. Contrary to Reclus' advice to wait for serious symptoms before operating, it would seem likely that very early operating might avoid the necessity of destroying the carotids, as the tumor grows somewhat loosely attached to the arterial wall, so that it might be easier to detach it.

CONTUSIONS AND WOUNDS OF THE NECK.

Popular imagination places the neck along with the heart and brain as one of the most vital centers of the body, whereas physicians know that it is made up of organs many of which can be severely injured without destroying life.

The popular fallacy is derived from the stories and pseudo-science of all ages, illustrating what Bacon called the *idola theatri* of the human mind, constantly opposing real knowledge. From the days of beheading by the broad-axe, the use of the bowstring of the Arab, or the sword and dagger of the warrior or assassin, to the garrotte, guillotine, and hangman's knot, the popular mind has constantly associated injuries of the neck with sudden death. It is still commonly believed that death is instantaneous when the neck is "broken." This explains the prevalence of cut throat in efforts at suicide. An individual versed in the anatomy and relations of the neck organs would scarcely attempt self-destruction by this method, or would choose a more certain route to the great vessels than by cutting across the larynx.

Contusions and crushing injuries of the neck are less common than in the head and extremities. Beside spinal fractures and cord injuries (cf. Chapter XXXV.), and those of the hyoid bone and larynx and trachea (Chapter XL.), the vessels and nerves are occasionally torn subcutaneously. Most injuries of the vessels are caused by wounds—gunshot, stab, and incised—and, as would be expected in this vascular area, are characterized by violent hemorrhages.

Cut Throat.—The injury known as cut throat is self inflicted in many cases. That it fails to cause death so often is explained by a popular ignorance of the fact that the great vessels are well covered in the upper part of the neck. In many reported cases the wound has been under the chin, where it divides the larynx or trachea, and where the thick muscles guard the great vessels somewhat. Going backward at the level of the thyroid cartilage, the cut needs to be very deep before it can injure either carotid. The firm cartilages have a considerable tendency to divert or check the knife. The same depth of cut just above the sternum or clavicle would incise one or all the great vessels of the neck. Hemorrhage from one of the carotids usually causes death before surgical assistance can be obtained. In the case of a large vein being wounded laterally, the bleeding may stop spontaneously or by light pressure.

Wounds of the air passages—the pharynx, the floor of the mouth, or the esophagus—may cause alarming signs of dyspnea from insufflation of blood. The rushing of air and bloody froth at the wound is less alarming to the surgeon than to the layman, but prompt surgical attention is needed to prevent complications from infection of the deep cellular compartments of the neck and of the bronchi and lungs. Repair of the various layers should be made as promptly as possible. The trachea, esophagus, or larynx, if divided, should be sutured separately, great care being taken that no openings are left from the lumen of either tube into the connective-tissue spaces. Dangerous abscesses develop more particularly after punctured wounds of the esophagus. In large incised wounds ample drainage of surrounding tissues must be provided when extravasation can occur. In smaller punctured wounds free incision

FIG. 182.—CUT THROAT.
Great vessels not wounded on account of high incision.

and packing may be required to enlarge the original wound and protect the adjoining tissues.

Wounds of the Blood-vessels.—The smaller vessels of the neck—thyroids, lingual, facial, vertebral, or occipital—can cause dangerous or fatal hemorrhages. When the *carotid* or the *internal jugular* is divided or punctured the time required for fatal bleeding is so short that few cases have been saved. That death can be prevented is, nevertheless, shown in cases reported by Lejars and by Larrey. In all of these the surgeon chanced to be near at hand and made immediate digital compression, which was maintained until the vessels could be secured. The stream or jet of blood in wounds of the carotids, innominate or subclavian, is large—the size of the finger—according to some observers. One woman, stabbed in the neck, is stated by Lejars to

have poured out three liters in a few moments. Such patients, as he observes, "Swim in their own blood and owe their lives, if saved, to the first surgeon who brings help. If left alone, death comes in a few moments." Digital compression must be employed instantly in such emergencies. The fingers must be thrust backward at the front edge of the sternomastoid until the great vessels are compressed firmly against the sixth cervical vertebra.

This may be called compression of the vessel in continuity. When it is not effective, more direct efforts to occlude the bleeding point should be made by thrusting one or more fingers directly into the wound. The cut in the wall of the vessel or its open end, if divided, may thus be found and the flow temporarily checked.

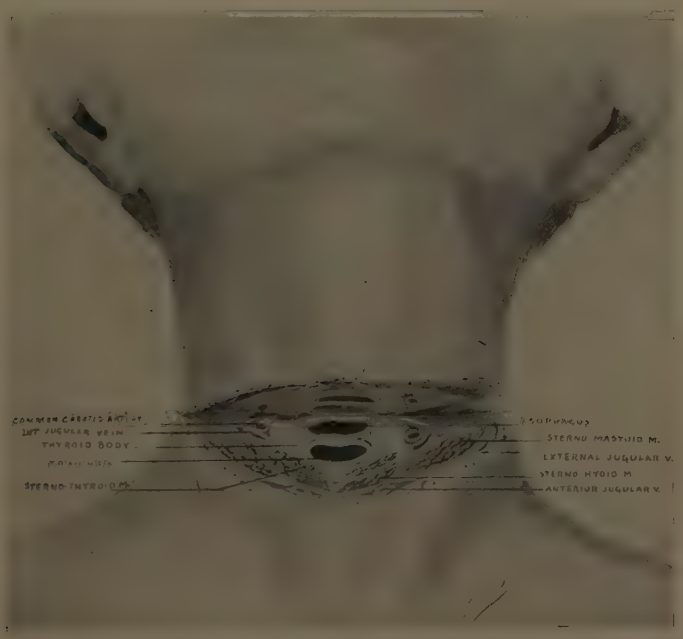


FIG. 183.—CUT THROAT, LOW INCISION.
Section showing relations of deep vessels.

Preparation should now be made for ligating the vessel. Small or punctured wounds may be enlarged and the main trunk of the vessel exposed enough to de-ligate or the open ends, if cut off, may be seized and closed by ligatures. The use of large forceps to seize masses of tissue in the hope of including the vessel is entirely improper, as the nerves, especially the vagus, are likely to be destroyed in this way, as are also the veins. The great difficulty of securing such a large vessel as the carotid in the bottom of a deep incised wound often makes it more advisable to incise the skin at a new point and ligate the main trunk in continuity proximal to the wound. The return bleeding from the upper cut end can sometimes be stopped by tampons, but usually

the external carotid or the common carotid on either side will need ligation before the return flow can be checked.

Wounds of the *internal jugular vein* have the additional danger of air embolism. This is as true in accidental wounding during operations as in case of ordinary wounds. A moderate amount of air entering a vein is not so dangerous as was formerly supposed. Such an accident during an operation is recognized by a hissing sound with inspiration. It has been noted many times on the operating table, and when quickly checked has caused no shock or disturbance, but if continued causes fatal collapse.

The hemostasis in wounds of veins is sometimes accomplished by external pressure. When wounded laterally the large vessels can sometimes be closed by fine sutures, as described by Ricord. The walls

FIG. 184.—DIGITAL COMPRESSION OF CAROTIDS. (Lejars.)

of veins, being thin and easily torn, hold ligatures and sutures rather poorly, so that in extensive wounds it is difficult to make perfect hemostasis. Unless care is used the vessel wall gives way under the forceps or ligature, and a deeper bleeding at once starts up which can only be controlled by enlarging the wound.

Secondary Hemorrhages.—The fact, well-known in the pre-antiseptic time, that infections caused secondary hemorrhage, needs to be emphasized in the surgery of the neck. A wound here which has gone a week or more in a suppurating state sometimes causes sudden and fatal hemorrhage from erosion of a great vessel or the sloughing off of the ligated end of a vessel. Provision should be made against this by keeping all phlegmonous cavities, as well as infected recent wounds, carefully drained and disinfected. Care as to posture and avoidance of movement, as well as constant watching of the patient, are also essential. Such accidents call for ligation of the vessels proximal and distal to the bleeding point. Even if the bleeding has stopped,

it is probable that it will be repeated, so that prompt interference is safer than expectant treatment.

Injuries of Nerves.—Any of the spinal nerves may be wounded by wounds or severe injuries, causing areas of anesthesia and local paralysis. The lower nerves forming the brachial plexus are not rarely injured, causing complete or partial paralysis of the arm and hand. Trophic changes may also follow. Such injuries call for immediate or secondary nerve suture.

The pneumogastric nerve is destroyed both in accidental wounds and in connection with operations on glands and injuries to the vessels.

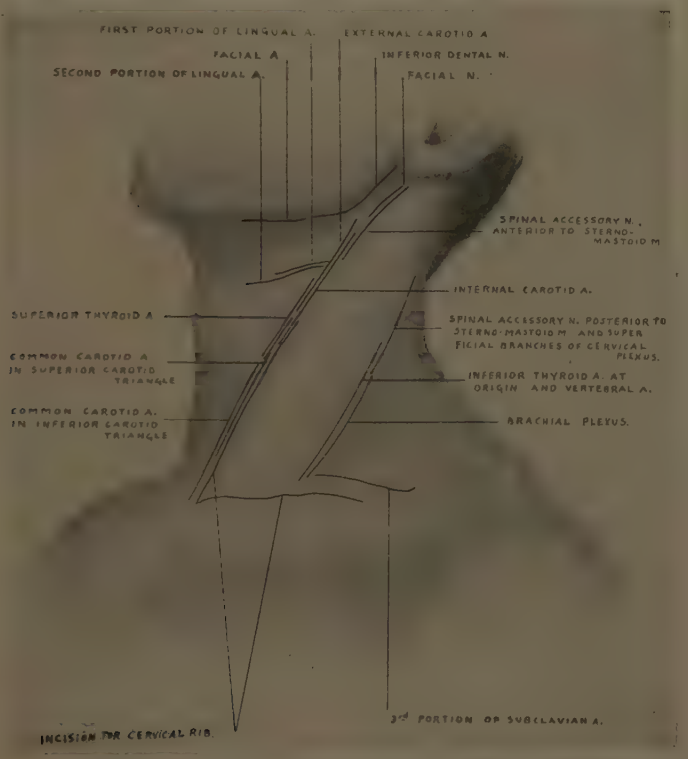

FIRST PORTION OF LINGUAL A.
EXTERNAL CAROTID A
FACIAL A
INFERIOR DENTAL N.
SECOND PORTION OF LINGUAL A.
FACIAL N.
SPINAL ACCESSORY N., ANTERIOR TO STERNO-MASTOID M
INTERNAL CAROTID A.
SUPERIOR THYROID A
SPINAL ACCESSORY N. POSTERIOR TO STERNO-MASTOID M AND SUPER. FICIAL BRANCHES OF CERVICAL PLEXUS.
COMMON CAROTID A IN SUPERIOR CAROTID TRIANGLE
INFERIOR THYROID A. AT ORIGIN AND VERTEBRAL A.
COMMON CAROTID A. IN INFERIOR CAROTID TRIANGLE
BRACHIAL PLEXUS.
INCISION FOR CERVICAL RIB.
3rd PORTION OF SUBCLAVIAN A.

FIG. 185.—INCISIONS FOR LIGATING VARIOUS VESSELS IN THE NECK.

Disturbance of pulse, respiration, and voice follow unilateral injury. It is thought by Ewald that the so-called vagus pneumonia is not frequent or dangerous.

When the hypoglossal nerve has been injured by wounds in the upper part of the neck, as in cut throat or punctured wounds, the tongue is paralyzed on one side, as to motion, but not as to sensation.

Injuries of the Phrenic Nerve.—The phrenic nerve is freely exposed in operating upon the retrosternomastoid glands and in penetrating wounds. In these operations often I find it descending vertically in the posterior part of the wound, lying upon the scalenus anticus,

and passing between the subclavian vein and artery. Probing or lightly punching it will cause a spasm of the diaphragm, thus enabling us to avoid it or protect it. The injury of one phrenic nerve paralyzes one side of the diaphragm. The dangers of this accident have been insisted upon by Erichsen, Hueter-Lossen, Diebel, Park, and Carless, who assert that it may cause sudden death by embarrassing respiration. On the other hand, internists, Bernhardt, Duchenne, and others, have determined that the gradual occurrence of phrenic nerve paralysis causes only slight dyspnea. Schroeder, in 1901, becoming skeptical as to the rôle of the nerve in causing death in the reported cases, took liberties with it in operations, and reported the first case of operative destruction of its continuity with no serious result. All previous cases reported had ended fatally. These were:

1. Schürmayer.	1847	Stab wound.	Right.	Death in few minutes.
2. Beck.	1848	Bullet wound.	Left.	Death on fifth day.
3. Bardeleben.	1882	Unknown.	..	Death in two hours.
4. Erichsen.	1884	Division while ligating subclavian artery.	..	Death in few days.
5. Mackenzie.	1891	Rupture from fall.	Right.	Death immediate.
6. Hearn and Keen.	1899	Resection during operation of phrenic and pneumogastric nerves; resection of jugular and rupture of thoracic duct.	..	Moderate temporary embarrassment of respiration; smooth recovery.
7. Schroeder.	1900	Division during operation.	Left.	Recovery.

Experiments were then made upon dogs, which showed that life could be prolonged in nearly every case after section of this nerve. Luschka had already shown, in 1853, that the fleshy portion of the diaphragm receives some innervation from the five lower intercostals. This can be verified in birds and mammals. Some compensation can therefore take place, and the paralyzed area of the diaphragm is only central, even if both phrenics are destroyed. The diaphragm is not an essential muscle of respiration in any event. It is true that section of one phrenic causes partial collapse of the lower lobe of one lung, but, nevertheless, the accident in man is not necessarily fatal.

Injury of the Thoracic Duct.—Wounds and injuries of the thoracic duct have been reported in not a few cases in recent years by Kirchner, Schroeder and Plummer, Cheever, Phelps, Keen, Boegehold, and others. Nearly all the later cases have been from operative wounds in connection with gland extirpation on the left side of the neck, but Kirchner's first 16 cases were from other accidents. The right side also may be the site of such an injury, because the lymph system is very aberrant, much more so than the venous system, and because a right thoracic duct often exists normally in addition to the left.

In nearly all the operative cases the main features were the same. While separating the glands from the subclavian or forks of the vessels a milky flow was observed (chylorrhea), proving the duct or some of its branches to have been divided.

The thoracic duct is 34 to 48 cm. in length, extending from the second lumbar to the sixth cervical vertebræ. It drains both lower extremities, the abdomen (except the upper part of the liver), the left lung, left side of heart, left arm, and left side of the head and neck. It is formed by a union of trunks from the intestines, chest, diaphragm, and receptaculum chyli. It has been objected very properly that the lumbar part should not be called the "thoracic" duct. The terms "ductus Pecqueteanus" and "ductus lumbo thoracicus" are suggested as more appropriate.

In this long extent of the duct as it passes through the diaphragm behind the aorta it is well protected. Nevertheless, it has been injured by blows and crushing of the chest in 16 reported cases. In 6 chylous ascites resulted and in 9 chylothorax. Boegehold's case was the first one due to wound of the neck. Keen added 3, bringing the number up to 20. The accident is not always fatal. Kirchner's case of a girl, aged nine, had a blow at the level of the third rib, followed by extreme distention of the thorax by chylous effusion. This was drawn off by puncture several times, and eventually the effusion ceased and the child recovered perfect health.

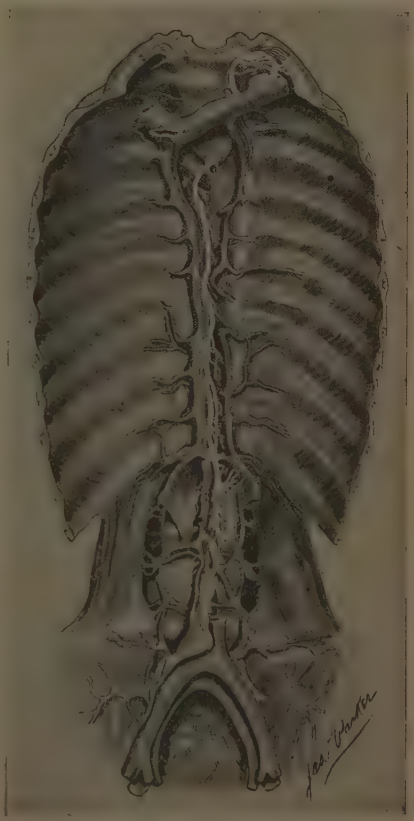


Fig. 186.—Origin, Relations, and Termination of the Thoracic Duct.

Vautrin has observed 4 cases of operative injury of the duct, only 1 of which had serious results.

Unterberger, reporting from Garrè's clinic in Koenigsberg, adds a case which recovered in fourteen days under packing. He collected from the literature (1906) 29 cases, including his own. The lack of uniformity in results of injury to the duct is explained by the great variation in its anatomy. Frequently the duct is double or triple and the injury of one branch is easily compensated. Teichmann devised the term "ductus hemithoracicus" for this condition. Not infrequently the duct is right sided or exists even on both sides, so that there is no immunity from danger of injuring it in operations on the right side. Szawlowski found 6 cases in literature, and added 6 more, in all 12, in which the right subclavian originated from the aorta direct, in which

the duct existed upon the right side. Watson reports a case of its emptying into the left axillary vein. Fyfe, Todd, Allen, Thomsen, Portal, and Redmond confirm this by similar cases.

"Delta" or forked double or triple entrance to the vein is reported by Quain, on the left side eight times, on the right side five times. A large number of cases are recorded in which the duct emptied into the vena azygos. Wendel, in 28 cadavers, injected the duct and found two unions with the azygos and four other anomalous connections to veins.

When the duct has been severed and there is no collateral branch, enormous outpouring of chylous fluid takes place, saturating the dressing and even the bed. The nutrition must suffer unless this can be checked. If the branch is ligated distention and rupture will

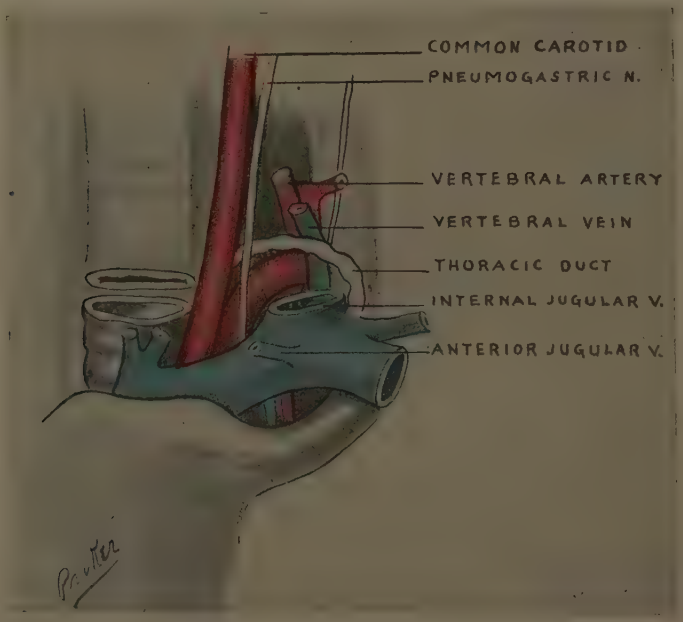


FIG. 187.—TERMINATION AND RELATIONS OF THE THORACIC DUCT.

follow unless collateral branches divert the flow. Hahn reports a case in which the duct was wounded, filling up the pleura. This was aspirated ten times, removing a total of 29,650 cc., or 30 quarts. Accompanying this great drain there is great thirst, weak pulse, and often syncope. Fever may be present from the resorption of nucleins and albumins in the wound. In other cases the flow is small in amount and even ceases when light pressure is made, indicating that the wound in the duct is a lateral cut or that branch vessels take up the circulation.

Treatment.—The treatment of a wounded duct may be by four methods:

1. Compression. 2. Ligation. 3. Suture (advised by Keen, Cushing, and Porter). 4. Implantation into a vein.

Sufficient data are lacking to establish clearly the value of any but the first two of these methods. Compression undoubtedly stops the flow in some cases and should be given a trial. Ligation of the wounded duct involves some theoretical risk, since with a single duct the patient must die unless it can discharge. To test this danger, Leuret, Lassaigne, Schmidt, and Boegehold tied the duct in numerous experiments, using dogs, horses, and other animals, usually causing no disturbance. It follows, as Vautrin is disposed to insist, quite properly, that we should tie the duct in all cases which discharge persistently. The risk is slight and the danger of not doing so considerable. The difficulty of finding the duct may be serious when it has to be sought in the retrosternal space behind the vessels. If this has to be done, it is safer and less difficult to do it before the tissues are much altered by inflammation, thus hiding the duct, and before the patient has become debilitated by loss of nutrition.

TUMORS OF THE NECK.

Cysts.—Cystic tumors of several distinct types occur in the neck.

1. **Congenital Cysts.**—The thyroglossal tract, instead of causing open fistulæ, leads sometimes to cystic tumors, as reported by Senn, Murphy, Haberern, and others. The differential diagnosis of these

FIG. 188.—CYST OF NECK AND OCCIPUT. (Schnitzler.)

cysts from other cystic diseases is often difficult. Lenzi and Pellegrini, reporting a series of such cases from their Florence clinic, point out two diagnostic features, the location in the median and lateral regions, where congenital fistulæ occur, and, histologically, the occurrence in the walls of the thyroglossal cysts of thyroid follicles. The treatment is extirpation, as in the fistulæ. When the deep or complex structure

of the cyst makes this impossible, the remoter parts may have to be left attached to the deep structures.

2. **Echinococcus Cysts.**—Echinococcus cysts of the neck occur in the subfascial spaces and often require a difficult dissection for removal. Haberern reports a successful operation for such a cyst in which the tumor, the size of a man's fist, was closely united to the internal carotid, requiring ligation. Other cases are reported by Beck and Makara. A total of 29 such cases appear in surgical literature up to 1907. Such cysts occur either in the thyroid gland or under the sternomastoid, where they form close connections with the great vessels. Ewald warns us that in the thyroid they may be mistaken for cystic goiter and in the deep location for branchiogenic cysts. An important diagnostic sign is the tendency of an echinococcus cyst, mentioned by von Bergmann, rapidly to enlarge by thrusting itself into free spaces, thus becoming loculated in form. The pathologic diagnosis can be made by aspirating the cyst, the contents of which are a clear, non-albuminous fluid, and by the finding of the characteristic hooklets of the echinococcus. It is important to remember that exceptionally the fluid aspirated, because it contains blood-serum or for some reason, may be albuminous. The treatment of echinococcus in the neck, as in other locations, is preferably by excision. Especial care is needed that the mother-cyst should be fully extirpated.

FIG. 189.—LYMPHATIC CYST OF NECK EXTENDING BENEATH CLAVICLE INTO AXILLA. (K. Ewald.)

3. **Lymphatic Cysts. Hydrocele of the Neck.**—These cysts are congenital in the neck, chest, or axilla in the region of the lymph-nodes. They form large thin-walled sacs in the posterior triangle, which are known as hydroceles of the neck. Such tumors are multilocular or single and consist of dilated lymph-spaces, such as occur normally in certain animals, as the frog. The gradual enlargement of such a cyst may lead to a secondary cyst in the axilla, as shown in Ewald's case (Fig. 189), which developed a fluctuating tumor, extending under the clavicle.

Puncture reduces these tumors temporarily, but is not curative. Attempts at removal have not usually been successful on account of the deep and complex connections of the lining membrane with the vessel walls and inner compartments of the deep fascia.

A spontaneous tendency to disappear in childhood characterizes the lymphatic cysts, even those of large size. The thin coverings contract and thicken, while the whole hydrocele undergoes shrinkage and finally is wholly absorbed. It is unusual, therefore, to meet with cases in adult life. Radical operation should be only a last resort. Jordan reports several efforts at extirpation which nearly cost the lives of the patients, and advises puncture, iodin injections, simple incision, or waiting for spontaneous decrease in size. Woelfler has practised incision and tamponing of the cavity to cause obliteration of its lining.

4. **Hemorrhagic Cysts.**—The neck is the seat of forms of cysts containing blood of most diverse origin and pathology. Weil described cases in which lymphatic cysts had become blood-filled or blood-stained spontaneously or after puncture. Franke described a case of cyst removed by operation which seemed to be an outgrowth from an angioma. Langenbeck's case was due to a varicose enlargement of the vein. Other cases histologically proved to be formed from the remnants of branchial cysts. Most of the reported cases had directly or indirectly to do with some vein. They may be differentiated from aneurysm by the absence of strong pulsations, but are liable to be mistaken for cold abscesses or other forms of cyst, unless aspiration of the contents be resorted to. In 9 out of 31 cases collected by Kahler the disease was congenital, and in the remainder appeared in early childhood.

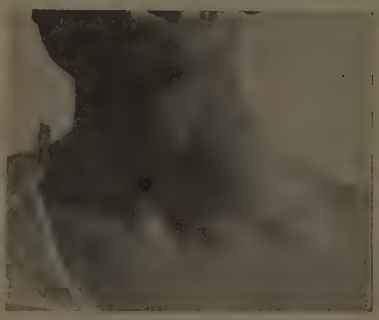


FIG. 190.—ANGIOMA OF NECK.

Treatment by extirpation may be called ideal, but has proved difficult or impossible in many cases. As a substitute for excision, iodin injection has been tried in suitable cases. This has proved dangerous, as in the treatment of vascular troubles by injection of irritants, in all parts of the body. Closed cysts, which have no free communication with any blood-vessels, are suitable for injection. Simple pressure by compresses bound over the mass is the least dangerous and has proved curative in several reported cases.

5. **Bursal Cysts.**—The occurrence of hydrops or distention of one of the natural bursæ of the neck gives rise to cysts so similar to those already mentioned that their diagnosis is often difficult or impossible except by aspiration and microscopic examination. These bursæ exist normally between the hyoid bone and thyrohyoid ligament, in front of the larynx and above the hyoid bone. They may become distended as a result of traumatism or of constitutional disease, rheumatism, pyemia, etc. The location of such cysts makes them liable to be mistaken for branchial cysts, aberrant thyroids, thyroglossal ducts, etc.

The ideal treatment of extirpation, as in bursæ in general, often is not easily carried out. The cyst, if simple and movable, should be

extirpated entire. When this is not practicable, drainage, tamponade, and iodin injections will bring about a slower cure.

Tumors of Lymph-glands.—Besides chronic tuberculous adenitis and lymphatic cysts, already mentioned, the lymph-nodes of the neck present several forms of new growths.

Malignant Lymphoma.—*Hodgkin's disease*, or *pseudoleukemia*, as defined by Billroth, usually makes its first appearance in the neck, remaining like a local disease for a time, and later, as if by a sort of metastatic process, developing glandular masses in other regions, axillary, cubital, inguinal, mediastinal, etc. Cough, anorexia, ascites, and anasarca gradually follow, with anemia, marasmus, and death.

FIG. 191.—HODGKIN'S DISEASE. (Pusey.)

The gross appearance of the enlarged glands is like that of a malignant growth, a hard, grayish-pink mass on section. Two forms of the disease are observed: A harder and a softer form. These forms reappear in the metastases in other organs. Microscopically, the masses appear to be made up of an enormous increase of lymphoid cells and connective-tissue stroma.

The treatment of Hodgkin's disease by *x*-rays has made a revolution in our ideas of the prognosis. Pusey has reported several cases clinically cured and remaining well after several years. The course of the disease before *x*-ray treatment was introduced was usually to a fatal termination in one or two years. Billroth's plan, perfected by Winiwarter, of using arsenic by injection, has been followed by occasional benefit, at least in delaying the fatal result. Fowler's solution is injected in full doses directly into the enlargements. The arsenic treatment is, at most, palliative. The writer saw this fail in one case, a middle-aged man with glands in both axillæ so large that the arms could not be placed against the body. Complete disappearance of all enlargemen followed *x*-ray treatment. (See also chapter on the Lymphatics.)

Lymphosarcoma.—Primary sarcoma of the lymph-nodes is believed by most pathologists to be independent of malignant lymphoma or Hodgkin's disease. While often not more malignant, its essential clinical difference is that it springs from a single focus in one gland and spreads not only to surrounding glands, but to all other adjacent organs instead of spreading at first to all parts of the lymphatic system, as does Hodgkin's disease. Microscopically, it has the structure of true sarcoma.

Lipoma of the Neck.—The back of the neck is a favorite location

for fatty tumors of the large single variety. These in some cases attain enormous size and hang pendant, like certain teratomata, upon the back and shoulders. Multiple or single lipomata also occur in the lateral region of the neck. These are usually in the subcutaneous fat, but occasionally appear in an interesting form in the intermuscular spaces. A large globular tumor filling the pharynx and seemingly attached to its wall was found by Andrews to be such a lipoma, the size of an orange, and removed by an incision behind the sternomastoid. It left a redundant wall of the pharynx, but no perforation.

FIG. 192.—HODGKIN'S DISEASE.

Carcinoma of the Neck.—Cancerous glands occur in the neck from metastatic infections as already described in Tuberculous Invasions. It is important that these relations should be understood in planning radical operations for malignant disease. The left side of the neck receives metastases from the abdomen by way of the lymphatic duct, notably in carcinoma ventriculi. Primary carcinoma, occurring in all the epithelial-lined organs, larynx, trachea, esophagus, and skin surfaces, and malignant growths of the thyroid, is discussed in another section.

THE SALIVARY GLANDS.

Congenital anomalies rarely occur in the salivary glands. Roser has reported a case of congenital fistula of the parotid, but most such affections result from accident.

The Parotid.—The external carotid artery and its branches, the temporal and internal maxillary, traverse the substance of the parotid, as do the facial nerve and the temporal and internal m llary veins. These relations and those of the internal carotid, together with the exposed position of Stenson's duct, and the fact that lower segments of the gland dip into the upper compartments of the neck, have an important bearing in operations upon this gland.

The parotid lies under the deep fascia on the side of the face and mastoid region, surrounding the ramus of the jaw and filling the space from the external ear forward and from the zygoma downward. Its cervical lobules fill the space beneath the mastoid process from the styloid process to the sternomastoid muscle. Stenson's duct crosses

the masseter muscle 2 cm. below the zygoma and enters the buccal cavity opposite the upper second molar tooth.

Parotid Salivary Fistulæ.—Wounds of the parotid may divide one of the branches of Stenson's duct or its main trunk and reunion may take place; but such accidents lead in some cases to salivary fistulæ. These are a source of extreme annoyance to the patient. The outpouring of secretion is profuse, especially at meals. Ulcerative processes, such as syphilis, lupus, or carcinoma, also cause parotid fistulæ. Operative treatment should be attempted by diverting these fistulæ into the buccal cavity and not toward extirpation of the gland or, even as suggested by Koenig, to ligation of its duct. It is true that in animals simple ligation has caused atrophy of the parotid, but this is uncertain and somewhat dangerous in practice.

The usual technic of implanting the fistulous end of the duct from the outer to the buccal surface of the cheek is that of Deguise. A

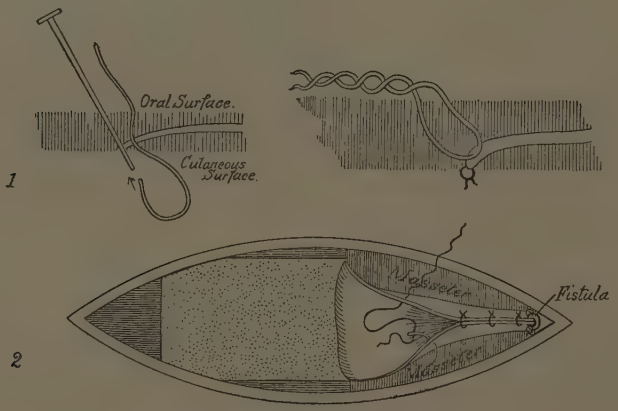


Fig. 193.—Operations for Salivary Fistula. (Binnie.)
1. Deguise's method. 2. Tube of mucous membrane.

small trocar is thrust through the fistula into the mouth, piercing the cheek at two points; a wire of lead is drawn through both punctures and tied in the mouth. If the skin wound now be sutured, or even left undisturbed, the lead will conduct the saliva inward and an epithelial-lined fistula later formed into the mouth. This method can only succeed when the opening is made in front of the masseter. The thick mass of that muscle will prevent a channel forming if attempts are made to pierce it. When the fistula lies over the muscle, the attempt was made by Nicoladoni to construct a tubular canal of the buccal mucosa to lengthen the duct. With very deep-lying fistulæ of a branch of the main duct he advises extirpating one lobe of the parotid. Efforts should be made to secure and utilize the distal part of the duct when the proximal part is too short for Deguise's operation. Weber dilates both the fistula and the normal duct outlet with catgut strings or laminaria tents, and then passes a string through both sections toward

the gland, so as to bring the parts in line. If they can be kept in position for a few days by this means the discharge enters the mouth and the fistula closes.

Parotitis and Abscess.—The parotid gland contains within its substance numerous lymphatics. These play an important part in tumors and infections.

Inflammations of the parotid occur from local causes, such as obstruction of the duct or by direct extension from the buccal cavity, and as metastatic infections after abdominal troubles in infectious fevers and pyemic conditions. Parotitis may be defined as a parenchymatous inflammation of the whole gland with catarrhal inflammation of the ducts and tubules of the secreting structure. The glandular acini eventually lose their epithelial lining and fuse into a purulent, necrotic mass, with the fibrous stroma when suppuration develops. Resolution may occur before great destruction has occurred, the gland being relieved by drainage through its own ducts. Tuberculous infection has been reported by Paoli, Bockborn, and Leoni. This may enter the gland by way of the embedded lymph-nodes or by the blood-current.

In acute infectious parotitis or mumps the painful, tender tumor disappears in a few days. In septic or metastatic cases the swelling persists; the edema, pain, and redness are more pronounced; the development of a phlegmon beneath the deep fascia often becomes evident and alarming general sepsis may set in. Extension to the brain in the form of meningitis or abscess of the brain is not unknown. Double parotitis is rather common, the two glands becoming successively the seat of infection in bad pyemic or septicemic conditions.

Prompt action is necessary in these infections to forestall complications. Before suppuration is recognized ice-bags may be employed. Early incision is demanded when pus is present. Such incisions must be deep and well planned to evacuate all contained pus and gangrenous débris. Especial care is needed in locating these incisions to make them parallel to the facial nerve and to the great vessels which traverse the gland. These cross its substance both transversely and vertically, so that extensive cutting, such as is done in the mammary infections, is impossible, but space enough exists for fairly free opening and packing of the abscess cavities.

Salivary Calculi.—Concretions in the salivary ducts are about five times more frequent in the submaxillary than any other gland. Czygan reports 37 cases in the Breslau clinic, the following being the order of frequency:

Wharton's duct	22
Submaxillary gland tissue	4
Stenson's duct	5
Parotid gland tissue	1
Sublingual duct	4
Bartholini's duct	1
Total	37

The presence of these calculi in some cases causes inflammation and even suppuration and perforation of the glands or ducts. Usually their irritant action is intermittent. They may grow until the size of a hen's egg is reached. Usually they have been detected and removed while small. Salivary cysts occasionally develop from obstruction by stones in the ducts. More usually the walls of the duct become thickened, forming a sac around the concretion, which occasionally becomes obstructed and is relieved by discharging around the stone.

The usual point of lodgment near the orifice of the duct makes surgical interference easy by incision through the mouth. The tumor should be cut down and the stone removed. It is rare that this can be done by merely splitting or dilating the orifice. In submaxillary

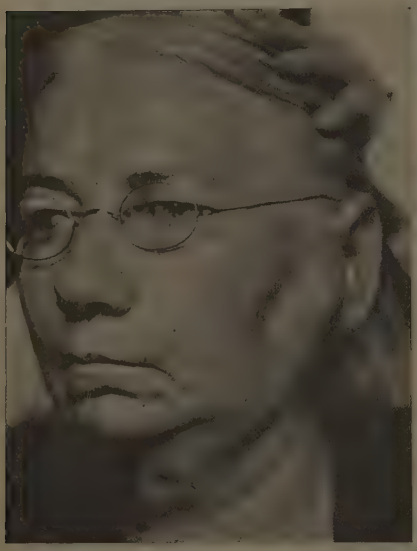


FIG. 194.—MIXED TUMOR OF THE PAROTID, EARLY STAGE. (Pusey.)

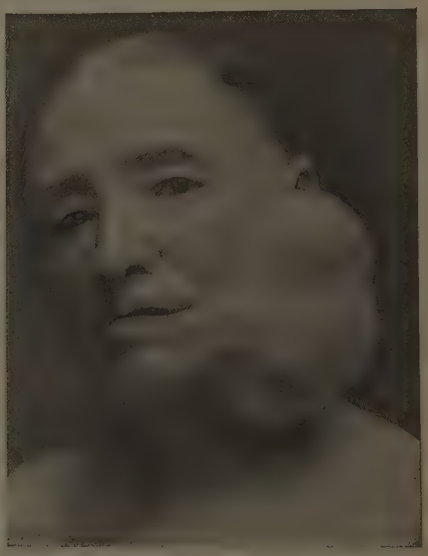


FIG. 195.—MIXED TUMOR OF PAROTID, ADVANCED STAGE.

gland concretions Mikulicz advises that the whole gland be removed. This is often advisable, as the operation is trivial and the danger of leaving inflamed or diseased gland is avoided. It is difficult to extract the calculus from the swollen and altered gland without damaging its structure seriously, so as to leave a possible fistula. The same rule should not be applied to stones in the parotid gland on account of the much greater danger attending removal of that gland.

Tumors of the Salivary Glands.—Under the term "mixed tumors of the parotid" (Billroth) are classified a variety of growths whose clinical identity is clear enough, but whose pathologic type is still under discussion. Koenig and Kaufmann recognize four forms of the parotid sarcomas:

1. Simple sarcoma. 2. Fibrosarcoma. 3. Myxosarcoma. 4. Chondrosarcoma.

These types mingle in the same tumor in the most curious manner, forming large so-called mixed tumors, containing various soft elements along with enchondroma or cartilage masses. Kelly, reporting 7 such cases from the Philadelphia clinics, shows that prior to von Bruns' researches wrong ideas existed as to the pathogenesis of these growths. They spring from a region containing diverse tissues, vessels, nerves, lymph- and secreting glands, etc., making it difficult to be certain which tissue was primarily affected. These tumors form at first movable nodules in front of the auricle. The retromaxillary fossa is soon filled up and the side of the cheek and mastoid regions are invaded (Figs. 194 and 195). Usually lobulated and hard, if myxomatous elements predominate, they may present soft areas. While the parotid, as stated

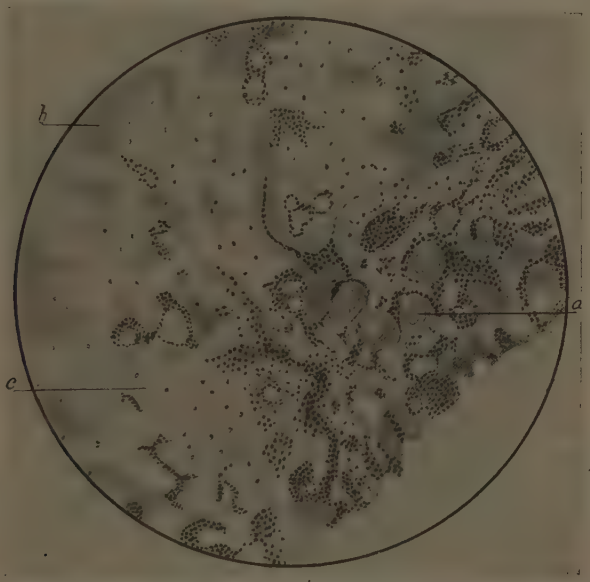


FIG. 196.—SECTION OF A MYXOCHONDROENDOTHELIOMA OF THE PAROTID.

Hematoxylin-eosin preparation; 90 x. *a*, One of a number of roundish or ovoid, glistening, highly refractive, pearl-like bodies, presenting a lamellated structure toward its periphery; *b*, decalcified cartilaginous tissue; *c*, myxomatous tissue. (Kelly.)

by Kelly, has no true fibrous capsule, it is so bound in by the compartments of fascia that the growth spreads in lines of least resistance, forward beneath the masseters, and downward into the neck, more than outward and backward. This is well shown in Keen's case (Fig. 197).

It is still doubtful whether the so-called parotid tumors always originate in the gland itself. von Bruns and most succeeding pathologists regarded them as epithelial in type, originating in the lining of the ducts or acini. They were accordingly classed as carcinoma, encephaloid, glandular hypertrophy, adenoma, or adenocarcinoma. This classification was based upon the resemblance of their cells to epithelium. Golgi classes them as endotheliomata. Most modern pathologists insist upon their connective-tissue genesis, as asserted by

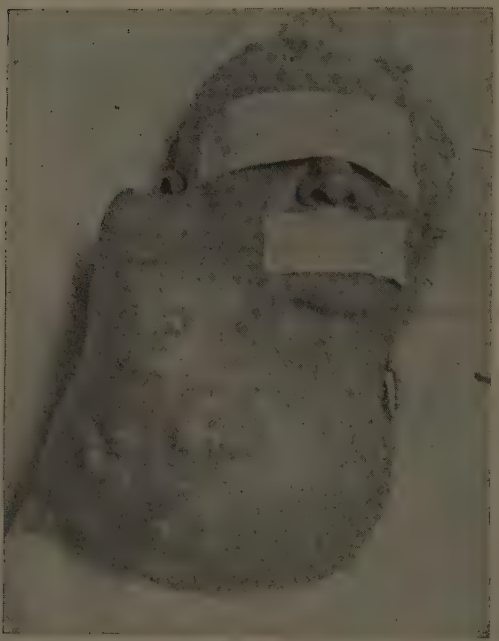


FIG. 197.—ENORMOUS MIXED TUMOR OF PAROTID. (Keen.)

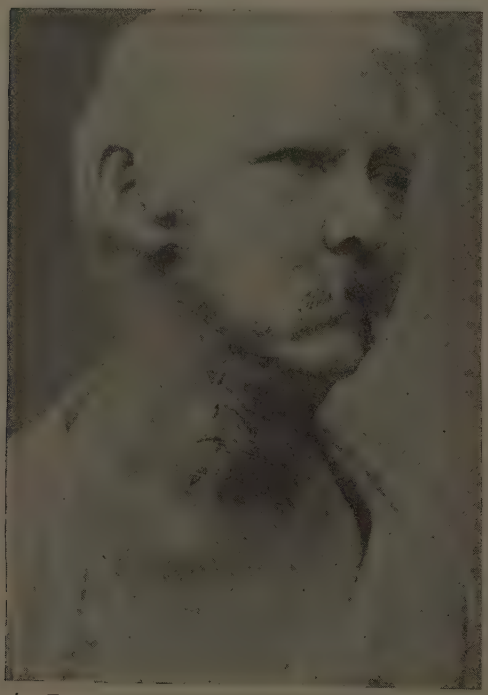


FIG. 198.—SAME CASE AS SHOWN IN FIG. 197. Result three months after operation. (Keen.)

Billroth and also by Volkmann and many others, grouping them with the sarcomas.

Histologically they are seen to contain many myxomatous and hyaline cylinders, called by Billroth cylindroma. Kolaczek asserted

FIG. 199.—LIPOMA OF NECK.

FIG. 200.—SARCOMA OF THE NECK. (Pusey.)

that the origin of these tumors was the capillary lining, and therefore classed them as angiosarcomas. They have also been termed telangiectatic myxosarcomas, perivascular sarcomas, and intravascular endotheliomas. The term endothelioma seems the best general one

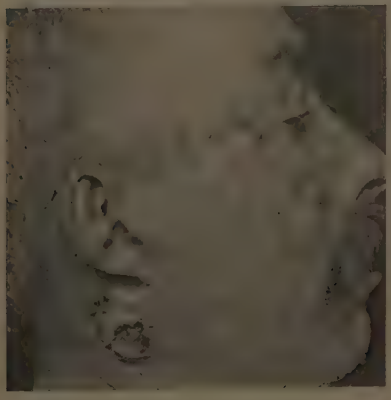


FIG. 201.—EPITHELIOMA DEVELOPED FROM A MOLE OR WART. (Pusey.)

FIG. 202.—CARCINOMA OF CHIN, SLOUGHING IN CENTER. (Pusey.)

for mixed parotid tumors. It has been shown that cartilage formation and hyaline deposit, such as they contain, are typical of endothelial tumors in general, so that the term myxochondroendothelioma, sometimes applied to them, is histologically correct.

These tumors are less malignant than some forms of cancer about the head and neck. Cures are reported after rather late operations, as the enormous one removed by Keen in 1904. This patient is still alive, without recurrence after three years, shown in Figs. 197 and 198. Operative removal is indicated as early as possible, with any metastatic glands. The external carotid and its branches and usually the facial nerve are destroyed. The vessels are first ligated above and below and the whole mass enucleated until its lower vascular connections can be ligated. The internal carotid usually does not pass through the mass and can be left internal to the line of section.

Cysts of the sublingual region, including ranula, are discussed in Chapter XLIV.

OPERATIONS ON THE NECK.

The various tumors above considered involve serious problems in their operative treatment by reason of their dangerous connection to the great vessels and nerves of the neck. The extensive removal of glands and adjacent fascia and muscle, such as characterizes the surgery of mammary tumors, was held impossible until the work of Crile showed that more radical and destructive surgery was practicable without destroying life. Butlin also advises radical extirpation of glands, especially those in the anterior triangle in malignant cases. His technic, as now employed, especially in cancers of the tongue, involves long incision from the mastoid process to the sternoclavicular joint, along the anterior border of the sternomastoid muscle. Another incision is carried from the symphysis menti across the neck to meet the first at about the upper border of the thyroid cartilage. These divide the skin into two large triangular flaps of skin alone or of very little more. The sternocleidomastoid muscle is retracted and its anterior border is cleaned so that the muscle is bare. The tissues between the sternomastoid and the muscles attached to the larynx are raised from below upward off the great vessels, which are left quite bare at the bottom of the wound. The dissection is carried up along the line of the vessels and deep down around them, in front and behind, particularly between the parotid gland and the vessels. The digastric triangle and the submental region are cleaned out thoroughly. The operation is not a difficult one. Butlin advises taking up, clamping, and tying every vessel before it is divided, so as to avoid hemorrhage. In this operation the removal of the contents of the anterior triangle means the lymphatic glands, the submaxillary salivary glands, fat, connective tissue, a portion of the omohyoid muscle, the platysma, quantities of veins, if the glands are adherent to it, and sometimes a portion of the external carotid artery.

Crile's Method.—After a long series of experiments on animals, Crile, of Cleveland, has developed a system of surgical technic for work about the head and neck which involves several new principles. Four cardinal points are involved in these improvements:

1. Anesthesia by intubation. 2. Control of blood-pressure by his

pneumatic suit (Vol. I., p. 939). 3. The use of temporary clamps on the arteries. 4. Massive or "block" dissection of large segments of the neck—muscles, fat, glands, and veins being removed in a single piece.

1. Closely fitting rubber tubes are passed through the nares into the pharynx opposite the epiglottis and closely packed around with a gauze tampon, while the tongue is drawn well forward. This gives complete control of the tongue. Mucus that might otherwise collect is absorbed by the tampon and is less likely to infect the wound. The anesthetist stands a short distance away and has entire control of the anesthesia.

2. Shock and collapse, so prone to occur during the extensive dissections of the neck, are minimized by using artificial support to the vascular system. Crile's pneumatic suit, together with the use of a

FIG. 203.—METHOD OF ANESTHESIA BY TUBES. (Crile.)

sphygmomanometer to measure the blood-pressure, furnish a method of precision for determining and regulating the vascular tension at every stage of the operation. The apparatus may be applied and the patient raised into an upright position, so as to drain the vessels above by gravity at the same time that all dangerous loss of tension is compensated by the suit. From time to time during severe operations the artificial pressure may be raised to meet deficiencies which occur in the heart action. At the end of the operation, when the patient is laid recumbent, the outside force is gradually relaxed and the balance of circulation restored.

3. Crile's clamps for temporary closure of the carotids have been tested in a large number of cases and been found safe and great conservers of blood. They enable us to attain somewhat the same bloodless condition which the Esmarch bandage secures in a limb. It is advised

that they be placed both below and above the site of operation, if return circulation seems active by way of the brain backward through the external and internal carotids, thereby arresting the reverse as well as the direct stream of blood to the parts. Care must be taken, as the inventor insists, to apply the clamps with "absolute gentleness."

Fenger employed temporary ligatures upon the deep jugular to prevent air embolism. As noted on an earlier page this can as well be done by placing a tampon against its wall. Crile's aim is usually to extirpate the large venous trunks and not, as so many former operators have advised, to ligate the carotid. Permanent closure of this artery has given a high death-rate from cerebral softening, approximately 25 per cent.

4. The three foregoing steps are fundamental to the real operative plan, "block" dissection of the neck, which is the crowning point of Crile's elaborate system, and may be said to mark a new epoch in the surgery of the neck and great vessels. While too recent to have had extensive trial at the hands of others, his own statistics are convincing. These included:

Under old methods	96 cases.
Living after three years	28, 29 per cent.
With "block" dissection	36 cases.
Living	19, 52 per cent.

The actual operative steps for "block" dissection are as follows: The anesthetic tubes being in place and the pneumatic suit applied, the latter is laced up and inflated to support the vessels in the limbs and trunk as high as the diaphragm or costal arches. The patient is

FIG. 204.—INCISION FOR REMOVING UPPER LYMPHATICS. (Crile.)

FIG. 205.—INCISION FOR "BLOCK EXCISION" OF THE GLAND-BEARING TISSUE OF THE ENTIRE SIDE OF THE NECK. (Crile.)

then inclined by lowering the feet, the common carotid exposed by an intermuscular incision above the clavicle, and the clamp applied to its trunk. The skin is divided by one incision partly around the neck below the jaw, and another descending incision from its center to the middle

of the clavicle. Another incision follows the ramus of the jaw from the symphysis to the mastoid and then descends from its posterior end. The skin is reflected back over the entire area of the field. The sternomastoid is divided, the internal and the external jugulars are secured, tied double, and divided at the base of the neck (Plate I). The dissection is then carried from below upward into the deep plane of the neck behind the lymphatic glands, working first at the sides, then posteriorly, carrying upward all the fascia, muscles, veins, fat, and connective tissue, until the floor of the mouth is reached (Plate II). If the growth is within the mouth the jaw is then divided at a safe

FIG. 206.—DEEP DISSECTION FOR GLANDS IN CARCINOMA.

A, Sternohyoid; B, digastric; D, internal carotid; F, carotid; G, sternocleidomastoid; H, submaxillary gland; I, hypoglossal; J, thyrohyoid; K, external carotid; L, omohyoid; M, platysma; N, Internal jugular. (Crile.)

distance on each side of the growth. The floor of the mouth and the border of the tongue are then similarly divided, completing the block.

In very critical cases an assistant experienced in the use and purpose of the sphygmomanometer is placed in charge of the management of the circulation. If the pressure falls below a certain point the pneumatic pressure is increased, and after the operation the suit is gradually decompressed, but in operations in the mouth in which there may be some oozing, and in which the posture of the patient may measurably prevent inhalation of blood, by continuing the rubber suit the patient may be allowed to come out of the anesthetic in the head-up posture. The pneumatic suit may be gradually decompressed after the circulation has reached a safe physiologic status.

Daugel reports recent cases of metastatic glands removed, with resection of the jugular, almost as radically as by Crile's method. In one patient, a man aged thirty-three, suffering metastases from a carcinoma of the jaw, he found it necessary to destroy both internal jugulars in removing the deep lymph-nodes. The operation on the jaw and glands was completed in one sitting. When the second jugular was tied there occurred sudden cyanosis and hyperidrosis, with a weak and rapid pulse. The alarming symptoms subsided in ten minutes and no cerebral trouble followed. After some time this patient died of erysipelas. An autopsy showed that the vertebral veins had become enlarged enough to carry on the circulation.

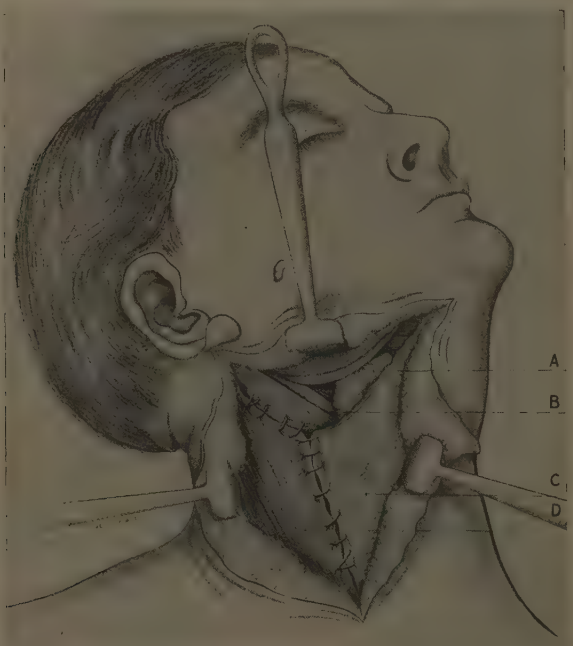
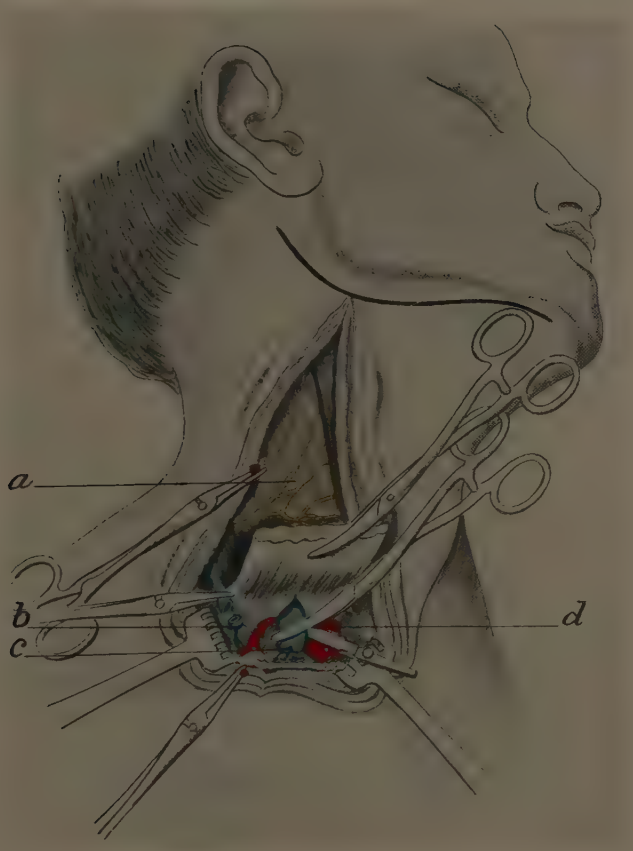


FIG. 207.—DEEP DISSECTION FOR GLANDS IN CARCINOMA (Continued).

A method of closing the deeper plane of the neck by suturing the longitudinally split border of the sternomastoid to the platysma and the digastric: A, Submaxillary gland; B, posterior belly of digastric; C, platysma; D, sternomaxillary gland; B, posterior belly of digastric; C, platysma; D, sternomastoid. (Crile.)

It seems certain that resection of the internal jugular is far less dangerous than ligating the common or internal carotid. It is not to be concluded from Daugel's case, however, that both jugulars can always be removed with impunity. He remarks that in his patient the veins had already been compressed, so that vicarious circulation was developing in advance of the ligation. Even single ligation has been shown by Linser to involve some mortality. Examination of a large number of skulls reveals the fact that in 3 per cent. one jugular foramen is so small that it could not transmit a large enough vein to compensate for both. If, therefore, in operating an unusually

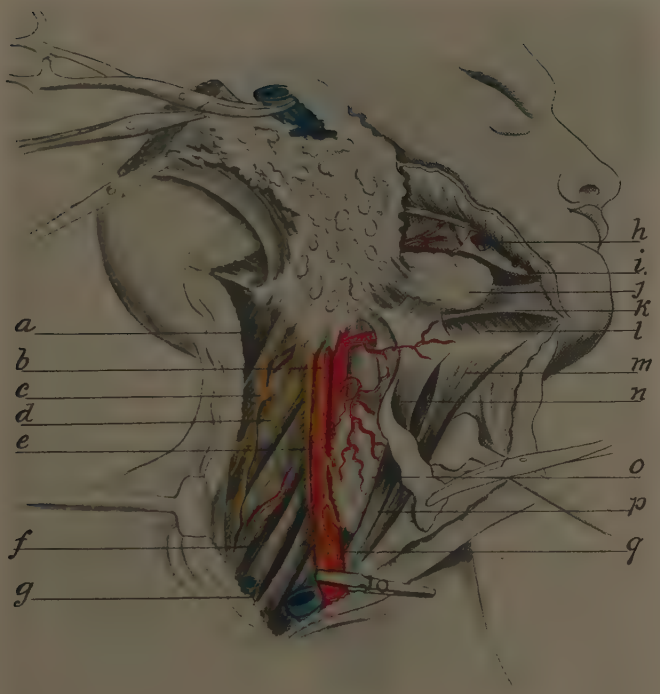
PLATE I.



CRILE'S OPERATION.

The sternomastoid is divided near the clavicle. The vein is exposed, tied in two places, and divided. The carotid is closed with a special clamp. The skin and platysma are then dissected back on the entire side of the neck. The deep plane of the neck down to the region having no lymphatic gland tissue is opened from below and laterally upward, and the relation of the sternomastoid muscle and the cervical fascia is noted. The complete exposure of the deep lymphatics is afforded by excision of this muscle. *a*, Sternocleidomastoid; *b*, external jugular; *c*, internal jugular; *d*, common carotid.

PLATE II.



CRILE'S OPERATION.

The entire mass of lymphatic gland-bearing tissue is excised *en bloc*, and handled as little as possible. The entire block of tissue is finally divided above, including the vein. *a*, Splenius; *b*, hypoglossus descendens; *c*, spinal accessory; *d*, levator ang. scapulæ; *e*, pneumogastric; *f*, scalenus posticus; *g*, internal jugular; *h*, facial vein and artery; *i*, submental; *j*, submaxillary; *k*, digastric; *l*, mylohyoid; *m*, sternohyoid; *n*, omohyoid; *o*, thyroid gland; *p*, thyrohyoid; *q*, carotid.

large internal jugular is met, care should be taken before ligating to ascertain whether the opposite jugular is of average size.

Cheever's Operation.—Transcervical incisions for reaching the pharynx and tonsils have been perfected by Langenbeck, von Bergmann, Küster, and Mikulicz, in the various operations bearing their names. The term "lateral pharyngotomy" broadly includes all these methods. They resemble external esophagotomy in certain steps. In several of them the incision divided the cheek and jaw bone. Cheever, of Boston, in 1870 employed a simple external route to the tonsil in malignant and other growths, not easily removed by the mouth.

A vertical incision is made in front of the sternomastoid about half the length of the neck. This is joined by a second incision parallel to the mandible (like Crile's incision, Fig. 204, but smaller). After dividing the deep fascia and drawing backward the sternomastoid, the tumor can be uncovered by drawing aside the great vessels and nerves. When the pharyngeal wall has been incised or torn widely in extirpating the growth, the wound may have to remain open into the pharynx during part of the healing. With moderate or small-sized growths the opening in the pharyngeal wall can be sutured and external drainage provided to prevent deep infection from the mucous cavity. This method is less radical than those of Langenbeck and others above mentioned, or that of Czerny, who divides all the structures from the angle of the mouth to the anterior border of the hyoid, the jaw being sawn across between the second and third molar teeth. It has the distinct advantage of being much less dangerous and less mutilating than these, and at the same time is far more efficient than the oral route for removing tonsillar growths.

THE THYMUS GLAND.

The thymus develops as a paired epithelial tube in fetal life from the third, fourth, and partly from the second branchial clefts. The epithelial elements become changed with development into the bodies known as Hassal's corpuscles (Gullard). The gland increases from birth until the second or third year, at which time it fills a space from the thyroid gland above nearly to the pericardium. It is, therefore, located in the anterior mediastinum, rising into the neck, where it can sometimes be recognized as an elastic, rounded tumor above the sternum, or by an area of dulness on percussion. It is a bilateral body, embracing the trachea.

Normally, the thymus disappears at puberty. Dudgeon and Fortescue-Brickdale describe a fibrosis as occurring at this period of the child's growth, ending in the extinction of the gland. Non-extinction or persistence of the thymus is pathologic. Rolleston classifies cases of persistent thymus as of three forms:

1. Simple persistence. 2. Hypertrophy. 3. Hyperplasia (Hassal's corpuscles do not share in the hypertrophy).

Sharp reported a case of supposed aberrant thyroid located behind the sternum, in which the histologic study revealed the presence of Hassal's corpuscles.

The function of the thymus is unknown. It was reported as early as 1614 by Plater that its enlargement sometimes caused sudden death in infants. The mechanical theory, that this accident results from pressure on the trachea, was set forth by Kapp, 1830, under the designation "thymic asthma." Friedlaender (1858) disputed and Grawitz (1888) revived the pressure hypothesis, while Paltauf (1889) again disproved it, showing that a general or constitutional cause existed.

In a typical example of the "thymustod," or thymus-death, there is stridulous breathing, a sense of suffocation, dyspnea, and rapid death. The *status thymicus* is a somewhat more chronic manifestation of similar derangement. There is hoarseness, feeble pulse, often convulsions and tetany, with a fatal termination. The occurrence is analogous to that caused by injury or destruction of the parathyroid bodies. Along with the enlargement of the thymus is often noted lymphatic gland enlargement and spongy swelling of the tonsils. Hemorrhagic swelling and tuberculous and suppurative inflammations occur in the thymus. The enlargement when morbid, especially in abscesses, has been detected by *x*-ray examination.

The treatment of enlargements of the thymus is mainly medical, by arsenic, mercurials, tonics, air, light, etc. *X*-ray treatment has not as yet given definite results. Operative treatment is indicated in abscesses, or in case of simple enlargement tracheotomy may be required to prevent suffocation. Castro reports 1 case in which life was prolonged somewhat by tracheotomy. Rehn secured a more permanent relief by opening the neck and drawing the gland upward, so as to relieve the trachea. It was suspended by sutures in its new location and recovery followed. Jackson, of Pittsburg, after securing temporary relief by tracheotomy, extirpated the thymus with permanent recovery.

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CHAPTER XXXVIII.

DISEASES OF THE THYROID GLAND.

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ANATOMY.

The anatomy of the thyroid gland is described in all surgical text-books. Only a few of the less generally known points are here mentioned.

The *isthmus of the thyroid gland* in most glands gives off a round, worm-like process at its upper extremity. This vermicular process is usually situated immediately in front or slightly to one side of the middle of the trachea or larynx, and varies considerably in length. It is called *processus pyramidalis*. In rare instances it extends upward as far as the hyoid bone.

The thyroid gland develops from a median proliferation of the ventral wall of the pharynx, which extends in a lateral direction. When rests of the ductus or tractus thyreoglossus persist it fails to become completely obliterated, there result accessory thyroid glands, *glandulæ thyroideæ aberrantes*, which are much more frequent in animals, especially in dogs, than in man. These bodies are found above or below the hyoid bone, in front of or behind the larynx and trachea, within the larynx or the trachea.

The *glandulæ parathyroideæ*, or true accessory thyroid glands, develop on the dorsal side from the third and fourth bronchial pouch, along with the embryonal thymus. They were discovered by Sandström in 1880 and are constantly present in man, although this is doubted by some authorities. They vary in number and position. There are generally four parathyroid glands, two on each side of the body (Fig. 208). In 6 per cent. of the cases examined fewer than four have been found. We distinguish two upper and two lower parathyroid glands: they are all embedded in the loose connective tissue which surrounds the thyroid gland and which is known as Kocher's external thyroid capsule. The upper glands are situated at the posterior median edge of the upper two-thirds of the lateral lobe; the lower glands are in relation with the upper pole of the thymus gland, usually below the lower pole of the thyroid gland, either in close apposition with the latter or separated from it by an interval of about 1 cm. The lower glands may also occupy a position on the posterior surface of the lower lobe, rarely on its anterior surface, and always at the level of the lower third of the thyroid gland. Not infrequently aberrant groups of parathyroid cells are found outside of and also within the

gland (Getzow). In displacements of the thyroid and in goiter the parathyroids are carried in the direction of the displacement of the external gland capsule and in proportion to its extent. The parathyroid glands are from 2 to 19 mm. in length, from 2 to 9 mm. in width, and from 1 to 4 mm. in thickness. In color they are brownish red; the surface is fairly smooth.

Relations of the Thyroid Gland.—The thyroid gland is situated underneath the superficial muscles of the neck—platysma, sternocleidomastoid, sternohyoids, sternothyroids, and omohyoids—and is surrounded by a thin layer of the deep cervical fascia, which forms the external thyroid capsule (Kocher). Along the posterior and median portions of the gland this capsule is adherent to the connective-tissue envelope of the trachea, pharynx, and esophagus; hence the thyroid gland moves up and down with the trachea and esophagus during the act of swallowing—a point of importance in connection with the symptomatology and diagnosis. One layer of the deep cervical fascia forms the sheath for the large vessels of the neck, which come in relation with the posterior outer portion of the thyroid along its entire length. In the external thyroid capsule are a large number of thyroid veins—*venæ accessoriæ* (Kocher). This external capsule also receives muscular fibers from the cricothyroid and sternothyroid muscles, which fibers have been described as muscles of the thyroid gland. On the median posterior aspect of the thyroid gland, in a groove between the esophagus and the trachea, the external capsule contains the recurrent laryngeal nerve.

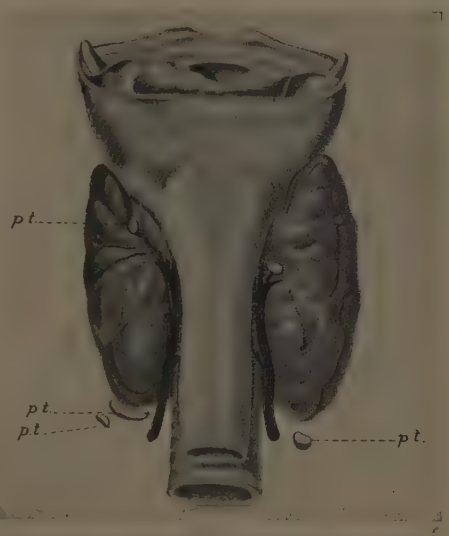


Fig. 208.—Parathyroid Glands (*p. t.*) of Man. They vary greatly in number and position. (Thompson.)

The *blood supply* of the thyroid gland is derived from two symmetric arteries, rather large compared to the size of the organ (Plate III). The superior thyroid artery reaches the upper pole of the thyroid gland, having a convexity directed upward and inward. Before entering the thyroid gland it divides into two branches: a large anterior and a smaller posterior branch. The anterior branch can usually be felt on the surface of the upper lobe along its anterior and median side as far as the isthmus, and gives off a separate branch, which is sometimes quite large, to supply the pyramidal process. In most cases the posterior branch enters the upper horn of the gland immediately below the bifurcation, but occasionally it can be felt along the

posterolateral surface of the gland. With rare exceptions the *inferior thyroid artery* is given off from the subclavian artery. In its upward course it describes a curve with the convexity directed inward and upward, underneath the common carotid and in front of or behind the recurrent laryngeal nerve, to reach the posterior external surface of the lateral lobe, where it divides just before entering the gland substance into two—rarely more than two—branches. The arteries are accompanied by several veins which bear the same names as the arteries; those which accompany the superior thyroid artery are more numerous and larger than the venæ comites of the inferior vessels. In many cases there is a third artery—*arteria thyroidea ima*—usually on one side only. It is a direct branch of the innominate artery and runs to the thyroid isthmus. At the lower pole of the gland the large *venæ thyroideæ imæ* are given off; their course is fairly straight and direct into the innominate veins. At the upper and lower border of the isthmus the two sides of the gland are connected by large veins, the venæ communicantes superiores et inferiores (Kocher). These numerous blood-vessels break up in the interior of the gland and form numerous smaller branches, which ultimately surround each individual gland tube as a capillary network, and come directly in contact with the gland-cells. The gland is accordingly extremely vascular, and its volume varies within wide limits in accordance with the amount of blood it contains. Similar plexuses are formed by the lymph-vessels and lymph-clefts, which unite to form small trunks on the surface of the gland, especially the anterior median portion of the lobes, and empty chiefly into the superior cervical glands; some also draining into the inferior cervical glands. This lymphatic network becomes much enlarged in large colloid tumors of the thyroid gland (Kocher).

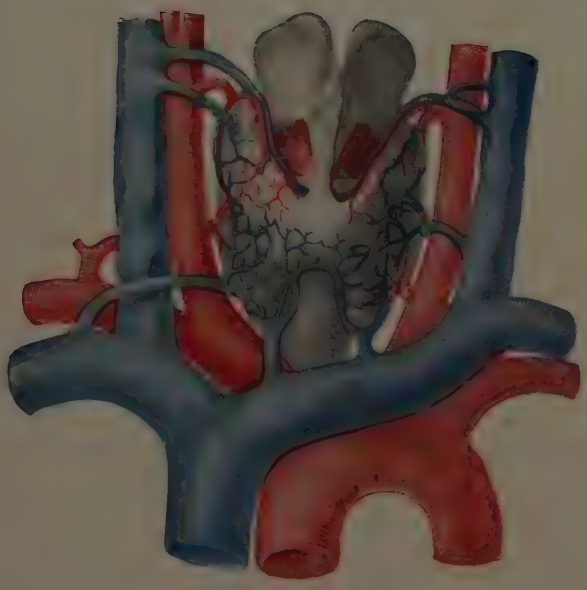
The *nerves of the thyroid gland* accompany and surround the blood-vessels; they are derived from the superior ganglion of the sympathetic and from superior and inferior laryngeal branches of the pneumogastric. No secretory fibers have as yet been demonstrated; the capsule of the thyroid glands contains sensory nerves.

Structure of the Thyroid Gland.—The surface of the thyroid gland is lobulated in a small pattern. In young individuals the color is dark red to dark bluish red; in older individuals it is more of a yellowish red. The section shows the same color and exudes a yellowish, clear, glistening, slightly sticky fluid, known as colloid material, in considerable quantities.

The *cut surface* of the gland is finely granular, corresponding to the individual lobules, with here and there projecting follicles of greater size.

In addition to the already mentioned external capsule, which is a continuation of the deep cervical fascia, the thyroid gland is surrounded by a *capsula propria*. This translucent, connective-tissue membrane, which in the normal gland is quite thin, does not strip readily because it dips into the interior of the gland, forming a network of connective-tissue fibers which become smaller and smaller as they

PLATE III.



NORMAL THYROID GLAND WITH ITS VESSELS.

Showing the superior thyroid artery, the inferior thyroid artery, the superior thyroid vein, the inferior thyroid veins, and the accessory thyroid veins.

penetrate farther into the gland. This network separates the individual gland-tubes and, by means of larger trabeculæ, effects an arrangement of larger or smaller groups—the gland lobules. This connective tissue

FIG. 209.—STRUCTURE OF NORMAL THYROID. (Leitz obj. 7.)

is known as the inter- and intralobular stroma, and carries the blood-vessels and nerves (Fig. 209). It also contains elastic fibers.

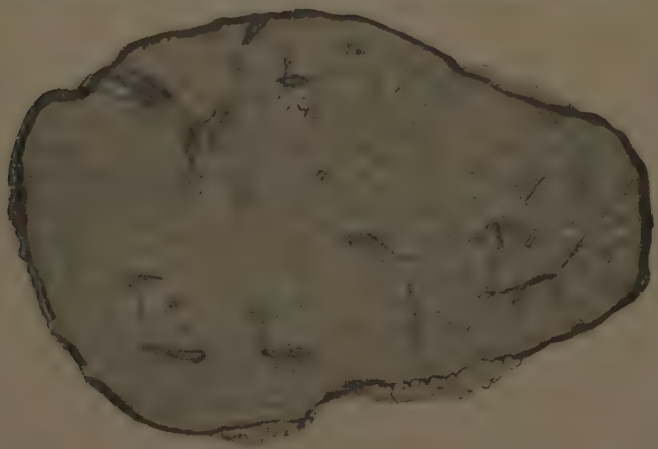


FIG. 210.—NORMAL PARATHYROID. (× 17.)

The *gland substance* is composed of individual gland-tubes which end blindly at each extremity and are called *follicles*. The contents of the follicles consist of *colloid* material, which varies in consistency. As a rule it completely fills the follicle.

The *accessory thyroid glands—glandulæ thyroideæ aberrantes*—have exactly the same structure as the thyroid gland itself.

The *parathyroids*—glandulæ parathyroideæ—have a quite different structure. They possess a thin connective-tissue *capsula propria* which sends out connective-tissue fibers into the substance of the gland. The stroma contains the blood- and lymph-vessels. In the upper parathyroids the blood-vessels form part of the plexus of the thyroidal vessels; the lower, external parathyroid gland, on the other hand, has a separate blood supply derived from the inferior thyroid artery and is drained by the venæ thyroideæ imæ, an arterial branch from the inferior anastomosis with the superior. The protoplasm is either finely or coarsely granular, and often clear.

FUNCTIONS OF THE THYROID AND PARATHYROID GLANDS.

The thyroid belongs to the ductless glands, which possess only an internal secretion, as to which our knowledge is quite imperfect. The epithelial cells of the follicles, which evidently represent its most important constituents, are capable of taking up certain substances from the circulation and altering them in some unknown manner. This so-called specific secretion is stored for a certain time in the follicular spaces and later enters the circulation. During this process the cells alter their shape and size, and according to this alteration several kinds of cells are distinguished, although their significance is as yet not accurately known. Many transitional forms are observed among these cells. Chemical analysis of the thyroid gland reveals the presence of albuminous substances—globulins and nucleins. Both occur in the cells as well as in the colloid material. The high iodin-content of the thyroid gland (Baumann) is its most characteristic feature, and the iodin-containing albumin of the gland (Baumann's iodothyrin) is capable of replacing the thyroid secretion. The amount of iodin contained in the thyroid gland varies and is usually proportional to the kind and quantity of colloid material present.

The largest percentage of iodin is found in the thyroid gland of the adult; in childhood and in old age it is much lower. Recent chemical and histologic investigations have shown a close relationship between the histologic structure and the iodin-content of the gland, and that both structure and iodin-content vary (1) with the functional state, (2) with locality, and (3) with nutrition.

There is no doubt that part of the secretion enters the blood stream, but we do not know in what condition. It is equally certain that the most important chemical constituents reach the circulation along with the colloid, since it is definitely known that the iodothyrin contained in the colloid, when given subcutaneously or by the mouth, is capable of replacing the function of the gland. In this process the iodin undoubtedly plays the most important part by entering into organic combination within the gland; hence the albumins of the thyroid gland have a specific significance. Thyroid glands totally devoid of iodin are quite rare; even the fetal gland contains some. Among 200 healthy and diseased glands we found only 2 with-

out any iodin, and these were obtained from cretins. It must also be borne in mind that when the demands on the gland are increased the amount of iodin diminishes.

We possess as yet but little accurate knowledge in regard to the subsequent chemical processes that take place in the material elaborated by the cells of the thyroid gland, but we do know the effects of *loss of the thyroid function* (determined first in man by Kocher in 1883, and in animals by Schiff in 1884) and the influence of the gland extract and of the iodo-albumins of the thyroid glands on the organism. We know that the internal secretion of the thyroid gland exercises a metabolic function in the organism, as a whole, or a function which assists in metabolism. The thyroid gland has a special influence (probably of a chemical nature) on the nervous system, and particularly on the vascular nerves (sympathetic system); next on the skin and epithelial structures; and finally on the osseous system and on the sexual functions.

The *function of the parathyroid glands* is not so well known. The glands do not conform to any of the known types of gland structure. The columns of epithelial cells, which anastomose in an irregular manner, are in contact at numerous points with the lymph and blood capillaries. The cells vary as to shape, contents, and capacity for staining in a manner analogous to the cells of the thyroid gland. Perivascular spaces similar to the lymph-spaces of the thyroid gland have also been demonstrated, but little is known about the chemistry of the parathyroids. Iodin has been found in them by Gley.

We have as yet no accurate knowledge in regard to the influence of metabolism in the cells of the parathyroid glands. Animal experiments —Gley, Vassale, Generali—have shown that the removal of all four parathyroid glands produces a fatal tetany which had previously been attributed to removal of the thyroid gland. Clinical observations appear to confirm the truth of this phenomenon in man. It appears, therefore, that the parathyroid glands possess an antitoxic function, that they attract toxic products of metabolism and prepare them for rapid excretion through the kidneys. The function is preserved if the two lower parathyroids remain intact, while the removal of all but one lower parathyroid usually leads to tetany, which, however, is not fatal. These facts, which were first determined by experiments upon animals, appear to be confirmed by clinical observation, which indicates, however, that even a partial parathyroidectomy is followed by certain important results, and that in such cases the mild form of tetany which is produced may become chronic, or rather relapsing, while in other cases epilepsy or epileptiform conditions are produced (Kocher). Hypoparathyroidism can certainly be recognized clinically and is observed particularly under certain definite conditions (*vide infra*). Erdheim and Mossaglia showed by animal experiments that the tetany of pregnancy is due to hypoparathyroidism.

The thyroid and the parathyroids, while not identical in function, are nevertheless not quite independent of one another. This is clearly

shown by their close relationship, by the blood supply of the two glandular systems, and by the fact that thyreoparathyreodectomy is less rapidly fatal than parathyreodectomy alone; that the symptoms are not quite the same in both cases; that the cachexia thyreopriva strumipriva, which never fails to develop after complete thyreodectomy, is less pronounced after thyreoparathyreodectomy, and does not appear in a pure form; and finally, that iodothyrin undoubtedly exerts a favorable influence not only on cachexia thyreopriva but also on cachexia parathyreopriva. There is no accurate parallelism, however, between the symptoms following loss of the thyroid function and the symptoms of aparathyreodea (Kocher).

Myxedema and Basedow's[1] (Graves') disease are caused by disturbances of the thyroid gland. The parathyroids are not altered in Basedow's disease (McCallum). On the other hand, Basedow's disease appears to run a more severe course, and recovery is more difficult in the presence of cachexia parathyreopriva or hypoparathyroidism; or possibly the disease is more apt to occur when hypoparathyroidism is present. It is, therefore, possible that the functions of the two glandular systems are interdependent in so far as the function of the parathyroids is partly, or perhaps chiefly, to take up the toxic or secretory materials of the thyroid gland and to prepare them for more rapid excretion through the kidneys.

FUNCTIONAL DISEASES OF THE THYROID AND THE PARATHYROID GLANDS.

Functional disturbances of the thyroid gland may occur secondarily in many diseases of that organ. Aside from this secondary disturbance, there are spontaneous or primary functional diseases of the gland which in their pronounced forms have long been known as definite diseases. They are *myxedema* and *Basedow's disease*. In the initial stages and in the abortive forms or "equivalents"—the so-called formes frustes of the French—their recognition is, however, quite difficult; and for this reason they have not been sufficiently appreciated; but as treatment is much more effective in this initial stage, early recognition of the disease is exceedingly important.

We subdivide the functional diseases of the thyroid and parathyroid glands (after Kocher) into (1) diseases due to *loss of the thyroid or parathyroid function* or secretion and (2) *thyreotoxic* or *parathyreotoxic* disturbances. The second group ought probably to be subdivided into hyperthyroid and thyreotoxic in the narrowest sense of the word.

Diseases Due to the Loss of the Thyroid and Parathyroid Function.—These include, in addition to the typical myxedema, cretinism, idiocy, mongolism, disturbances of growth, obesitas thyreopriva, disturbances of the sexual functions; and psychoses, neuroses, disturbances of sensa-

[1] This disease was first described by Graves in 1835, and should be known by his name. Basedow did not describe it until 1840, yet German writers usually but wrongly call it after the latter. Science should know no nationality. The name of Basedow is retained in the text, since the author of the chapter uses it.—EDITOR.

tion, epilepsy, and tetany. It is now definitely established that tetany is due to loss of the parathyroid function. It is quite probable that also the other of these diseases which chiefly manifest themselves in the nervous system are, in part at least, due to loss of the parathyroid or thyroid functions, or of both.

The symptoms of the diseases due to loss of the thyroid function are: (1) Interference with the growth of the body in height, manifesting itself chiefly in the bones by a characteristic persistence of the epiphyseal lines. (2) *Changes in the skin and epithelial structures.* Myxedema, properly so-called, or swelling of the skin and subcutaneous tissue, manifesting itself first and chiefly in the eyelids, lips, nose, cheeks, and hands. The skin has a pale, anemic, transparent, and waxy appearance; the swelling is soft and elastic, not edematous; the hair falls out or is imperfectly developed on the scalp and on the surface of the body, as are also the nails and the teeth; dryness and desquamation of the skin; yellowish-brown pigmentation. (3) *Depression of the circulation.* Small, slow pulse of low tension; low blood pressure; coldness of the extremities; blue hands and feet; subnormal temperature; cardiac dyspnea on exertion; frequent attacks of syncope. (4) *Myxedema of the mucous membranes,* associated with anorexia and constipation. (5) *Menorrhagiæ.* The symptoms are intensified during pregnancy; when the disease appears early, the sexual organs fail to develop. (6) *Symptoms referable to the nervous system.* Lassitude, apathy, depression, retardation of physical and mental reaction; pain in the limbs, especially on exertion; psychopathies; loss of self-control; melancholia, phlegmatic disposition, muscular rigidity, epileptic and tetanic attacks (loss of parathyroid function). (7) *Changes in the metabolism.* The quantity of urine is diminished; the specific gravity is low; the excretion of urea and nitrogen is diminished, as well as the albumin metabolism and the consumption of oxygen. (8) *Blood.* The number of red blood-cells is usually diminished to 3,000,000 or 4,000,000 per c. mm.; the hemoglobin is correspondingly or, more frequently, disproportionately diminished; the color index is subnormal; poikilocytosis is rarely present; the leukocytes are also diminished, particularly the neutrophiles, while the lymphocytes are usually not diminished, and therefore relatively increased. A slight increase of the eosinophile cells is frequently present. The viscosity of the blood is increased. (9) *Thyroid gland.* There is always some change in the gland, either congenital or acquired. The

Fig. 211.—Marked Cachexia Thyreopriva.

functionating parenchyma is diminished, and the blood and lymph circulation impaired; or there is total absence of the thyroid gland, owing to a primary developmental anomaly.

Causes of Diseases Due to Loss of the Thyroid Function.—The causes are various, but in the majority of cases are closely related to the cause of goiter. The onset of the disease usually bears a relation to some physiologic or pathologic alteration of the gland.

The *course* depends on the degree of hypothyrosis or, in other words, the quantity of functionating parenchyma still present. A man can live about seven years without a thyroid gland, and then dies with gradually increasing cachexia (Kocher). In congenital myxedema the expectation of life is somewhat longer, although we know of no cases of total absence of the thyroid gland in which the individual lived beyond the age of twenty-two years.

Treatment.—Uninterrupted exhibition of thyroid gland preparations may hold the diseases in check permanently, and the earlier the treatment is begun the more perfect will be the recovery. The exact methods of treating the various forms of diseases due to the loss of thyroid function must be determined by future investigations; particularly to what extent we shall be able to differentiate between diseases due to loss of the thyroid function and those due to absence of the parathyroid secretion. The special treatment of those cases also in which, instead of total absence, a mere reduction of glandular parenchyma is the cause of the disease, will no doubt be considerably improved by a further study of absorption and secretion and the chemical foundation underlying these functions.

The *surgical treatment* of these diseases consists in the implantation of normal thyroid gland tissue obtained from man or from an animal, and, when successful, is better than any other. The conditions for implantation are a piece of gland that is capable of functionating and also of developing, and a favorable implantation soil. Multiple subcutaneous implantation (Christiani), implantation of splenic tissue (Payr), of thyroid gland capsule, subserous implantation, implantation into the bone-marrow (Kocher), have all been tried. We are not as yet in a position to make any definite statements in regard to the implantation of parathyroid tissue.

Thyrotoxic Diseases.—The symptom-complex known as *Basedow's disease* represents the well-developed form of these diseases. If we wished to unite all the diseases that belong to this type under one heading, we should select as the best name for the group thyrotoxicosis.

Etiology.—Thyrotoxicosis may be (1) exogenous, (2) endogenous, or, in other words, due to the entrance of substances from without or to the production of substances within the body. These substances may develop a toxic action depending on their quantity or quality. They may either be necessary to the organism or may be foreign to it; they may be normal products of metabolism or may be formed by some pathologic process; their toxicity may be due to retention or to too rapid absorption and excretion. The characteristic and most important

feature of thyrotoxicosis is that the intoxication of the organism is carried on *through the thyroid gland*, as the invariably good effects of operations on the thyroid gland show. Accordingly, thyrotoxicosis develops chiefly during the period of greatest functional activity of the thyroid gland, between the twentieth and the forty-fifth years of life.

The **symptoms** are very numerous and by no means the same in every case. We frequently find the symptoms more or less pronounced, according to the treatment that has been employed. In recent cases, and before treatment of any kind has been instituted, the clinical picture is fairly uniform, but different if the disease begins suddenly or develops slowly.

Typical Symptoms.—The thyroid gland is enlarged in all its parts and shows distinct signs of increased vascularity (thrill, blowing murmur, expansive pulsation, enlargement of the arteries). The consistency is accordingly quite soft; on deep palpation, however, the gland feels firmer than the normal gland, *i. e.*, there is a loss of elasticity. These changes develop, as a rule, in a gland which previously had been normal on palpation, and sometimes they are preceded by a diffuse enlargement of the thyroid, but rarely by the condition known as nodular struma or goiter. The enlargement and the vascular phenomena are more marked when the onset is sudden. This clinical alteration in the thyroid gland is proportionate to the severity of the disease. When the disease has lasted a long time, and particularly after treatment has been applied, the gland may harden and the vascular phenomena may diminish; but they can be demonstrated at once after any excitement.

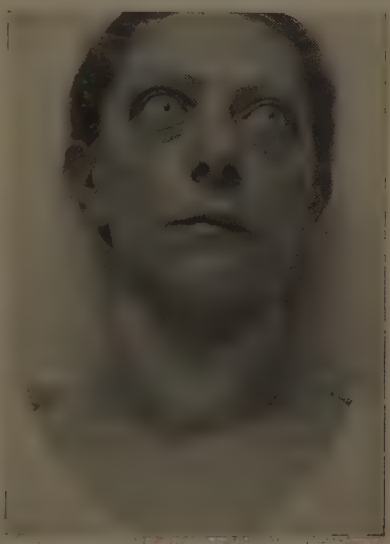


FIG. 212.—HYPERTROPHY OF THYROID GLAND IN THYROTOXICOSIS.

Symptoms in the Circulatory System.—The most important is *tachycardia*. The pulse is abnormally frequent, quick, usually of high tension, and extremely irritable. The heart beat is forcible; there is dilatation, sometimes occurring only during excitement and after exertion, or increased by these conditions. Cardiac and vascular murmurs produced by the increased velocity of the blood; capillary pulse; congestion; a constant feeling of heat; frequent hemorrhages, chiefly from the nose and gums. In acute cases all these symptoms develop at once; when the course is more deliberate, they develop gradually or appear during periods of exacerbation only; the pulse then often becomes irregular, especially when the disease is protracted. In well-marked cases the blood pressure is usually increased, often very

much so; fall in the blood pressure indicates insufficiency of the heart and is an unfavorable prognostic sign.

Symptoms in the Nervous System.—Psychic and bodily unrest and irritability are characteristic symptoms. They may go on to the production of psychoses. Other characteristic symptoms are insomnia and tremor, chiefly affecting the hands, arms, legs, tongue, and lips—more rarely the eyelids and pupils—and sometimes becoming general; headache and neuralgia are rare.

Exophthalmos.—This occurs chiefly in the acute cases, particularly when the symptoms are brought on by some intense emotional excitement. Increased width of the palpebral fissure, infrequent winking, want of coördination between the movements of the lid and those of the globe on looking downward (Graefe's sign, lagging of the lid) and on looking upward (Kocher), sluggish convergence are not constant, but very conspicuous when present. The psychic expression of the eye betrays great unrest and anxiousness. The eyes are staring when an object is fixed, and often have a peculiar, shiny look.

Skin.—The skin is moist and the patients perspire freely, especially during excitement and exertion, the secretion being most marked on the palms of the hands and under the arms. The hair, including that of the eyebrows, falls out and becomes paler in color. The skin becomes thin and translucent; the nails crack and are marked with longitudinal lines; the teeth also become brittle. The vasomotor nerves of the skin are extremely irritable and well-marked dermographia is often present. The skin is red and injected and frequently the seat of pigmentation.

Metabolism.—Metabolism is increased. Temporary attacks of indigestion without apparent cause are frequent, and the stools are often quite watery and very numerous for long periods at a time. This diarrhea, as well as the nausea and vomiting that may be present, are partly of nervous origin.

Great lassitude, diminished resistance to fatigue, weakness, and emaciation affecting chiefly the subcutaneous fat and also the muscles, are important symptoms of the pronounced stage of the disease and are never absent in severe cases; otherwise, however, they are not always present. They are among the earliest symptoms to be influenced by internal treatment.

The bones may become slender and delicate; the capsules and ligaments of the joints, particularly of the fingers, relax by overextension. Some patients exhibit a peculiar wabbling gait, which suggests congenital dislocation of the hips.

The *menstrual flow* diminishes or ceases altogether. The *cervical lymph-glands* in the distribution of the thyroid artery are slightly enlarged. Not infrequently the thymus persists and there is hypertrophy of the entire lymphoid apparatus.

The *blood* exhibits characteristic changes which recent investigations (Kocher) have shown to be constantly present, so that the diagnosis can be made from the blood picture even in abortive forms of the

disease. The number of the different varieties of normal leukocytes undergoes alteration and the number of leukocytes as a whole is slightly diminished. The neutrophile leukocytes, which are most numerous in normal blood, are diminished sometimes to half their normal number, so that they may be less numerous than the lymphocytes; the latter are increased sometimes to twice the normal number, and even if there is no absolute increase, there is always a relative augmentation. The eosinophile leukocytes are usually also diminished, but may be slightly increased, particularly in cases that are not uncomplicated. The number of the red blood cells is almost always normal, as is also the percentage of hemoglobin. The viscosity of the blood is usually lowered so that it coagulates more slowly.

Course.—We are not yet in a position to give precise descriptions of the various forms of thyrotoxicosis. There are cases in which the disease is *acute*, or characterized by *acute exacerbations*, and runs a rapidly fatal course. The cases in which the exacerbations are less acute are usually terminated by an intercurrent disease. The complications, such as angina, catarrh, or influenza, which bring on or are followed by the exacerbations are usually not in themselves dangerous. During the exacerbation all the symptoms increase in severity, and death is directly due to overexertion of the heart with excessively rapid pulse. The heart becomes enormously dilated, the pulse very irregular, there is delirium cordis, and the patient finally goes into collapse with edema, albuminuria, fever, dyspnea, enlargement of the liver, anuria, and excitement, which may go on to delirium and finally end in unconsciousness. A similar course is observed in those cases which end fatally after operation and in which a relatively insignificant complication, such as those mentioned above, or even the use of morphin or the administration of an anesthetic, is the cause of the exacerbation. The accident occurs, it is true, only in very severe cases, and can be avoided by suitable preliminary treatment.

In *chronic cases of thyrotoxicosis* many of the symptoms present in the well-marked form of the disease, such as tremor, exophthalmos and the remaining eye symptoms, sweating, falling of the hair, digestive disturbances, emaciation, and disturbances of menstruation, are permanently or temporarily wanting. There remain then the following positive signs of thyrotoxicosis: Vascularity of the thyroid or struma, tachycardia, psychic and bodily unrest, and the changes in the blood. These symptoms are increased by excitement and exertion, which also bring on other symptoms that may be of use in establishing the diagnosis. In some cases of thyrotoxicosis there is marked pigmentation of the skin resembling that of Addison's disease; others are attended by obesity, glycosuria, tetany, epilepsy, psychoses, neuralgias, paralyses, trophic disturbances, diseases of the skin, especially urticaria, and, finally, distinct symptoms of loss of the thyroid function, the latter almost exclusively relating to the integument.

The study of these atypical cases is particularly important for the purpose of distinguishing between the various forms of thyrotoxicosis.

Course of the Disease.—This depends very much on the treatment. If the disease remains untreated, it is usually progressive, as we see in cases occurring in individuals belonging to the working classes who are not in a position to avoid overexertion. The disease is less common among working people, but, on the other hand, usually runs a very rapid course and a fatal termination is comparatively frequent. Cases of this kind also illustrate better than any others the good results obtained by *operative treatment*, which are so prompt that the patients are able to return to their work in a relatively short time. On the other hand, *suitable treatment* may accomplish a good deal, provided it is begun quite early. If the injurious influences which affect the thyroid gland, particularly at the time of its greatest activity, are avoided

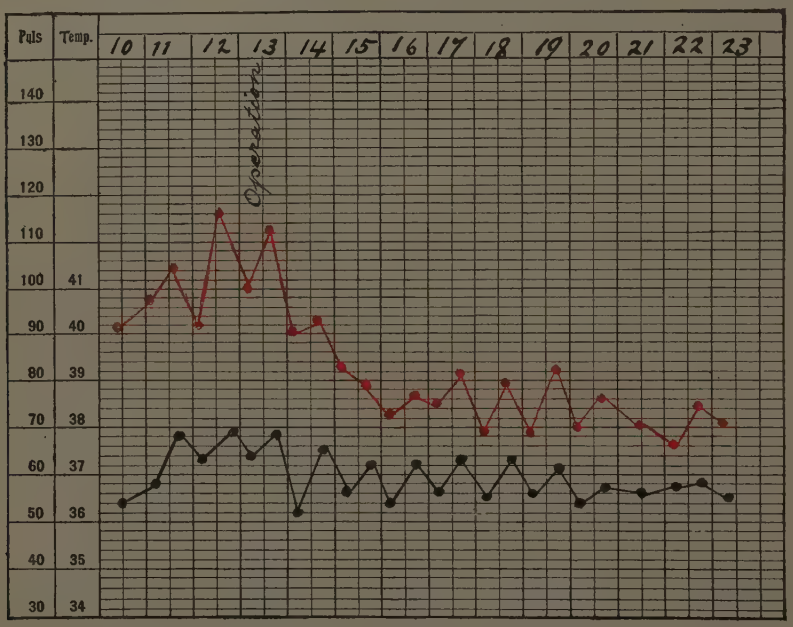


Fig. 213.—Chart of Temperature and Pulse in Thyrotoxicosis. Shows the slowing of the pulse that follows operation.

and the function of the gland is reinforced, the early symptoms of the disease, which are particularly apt to occur at this time, do not make their appearance, and a severe or sudden outbreak of the disease from causes acting later on is thereby avoided. For the rest, the course of the disease depends on the treatment and on the patient's behavior. If the disease develops suddenly the course is more grave and the prospect more gloomy than when the disease begins slowly. Remissions of greater or less duration are quite characteristic, and there is a great tendency to relapses and exacerbations which, in view of the above-named causes of the toxicosis, is not to be wondered at.

Pathology.—The changes in the nervous, vascular, and sympathetic system are functional or degenerative. In acutely fatal cases

we find degenerative changes in the heart, blood-vessels, liver, kidneys, muscles, mucous membranes, and serous membranes, which are the same as those seen in other intoxications. The only positive signs of functional alteration, which are present in every case, are found in the thyroid gland. These changes are present both in the very early stages and in the atypical forms of the disease. Our own pathologic material now comprises more than 120 thyroid glands, a small proportion of which were examined post mortem, while the majority were obtained at operations. They came from all over the world. In the main, the disease is rarer in warm, southern countries than in northern latitudes. It is just as frequent in goiter-regions as elsewhere, with the difference, however, that many cases in the goiter-regions run a

FIG. 214.—GOITER IN THYROTOXICOSIS.

milder course, partly because they come under observation earlier on account of the presence of the ordinary goiter, and partly because goiter formation, inasmuch as it reduces the quantity of functionating tissue and impairs the vascularity, is antagonistic to thyrotoxicosis.

There are five important factors in the pathologic diagnosis of functional Basedow's disease of the thyroid gland: (1) The vascularity; (2) the extent of the histologic changes; (3) the chemism of the gland; (4) the duration of the disease; (5) the previous treatment.

The characteristic histologic changes, which in recent times have been described by so many authors, can be regarded as specific only when the above-mentioned factors are taken into account. These changes are: Irregularity in the arrangement of the *alveoli* (acini); localized changes in the *epithelium;* the formation of papillæ; increase in size, particularly in the height, of the epithelial cells, which are paler in the

central portion and darker in the peripheral part where the large vesicular nucleus is situated. The *colloid* material in the areas where the epithelial cells are high is retracted and granular; where there is circular hypertrophy of the cells the colloid material is flaky and is often found only at the center. In the smaller alveoli the cells are also high and do not contain viscid, tingible colloid material. Interstitial and intra-alveolar lymphocyte infiltration, with desquamation of epithelial cells and foci of lymphocytes resembling germ centers are either quite extensive or only sparingly present. Chemical analysis of the thyroid gland in Basedow's disease shows that the metabolism is quite variable; the gland may take up an abnormal quantity of iodin, out of all proportion to its size or the amount of colloid it contains; but it may, under certain circumstances, lose the iodin with the same rapidity. It is

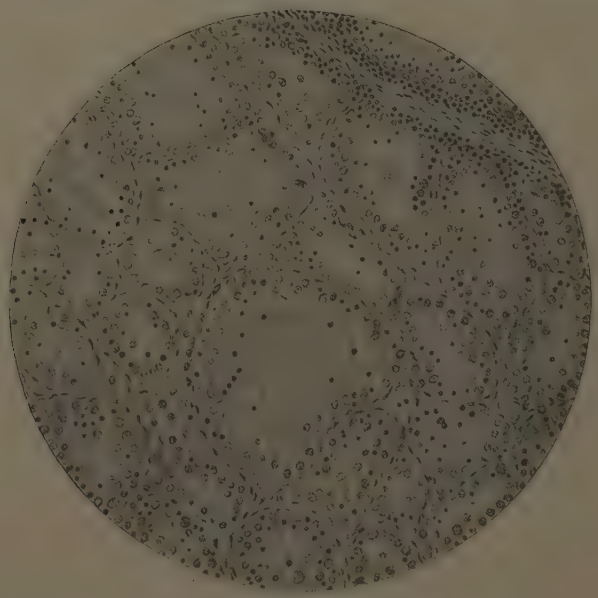


Fig. 215.—Goiter in Thyrotoxicosis.

noteworthy that in thyrotoxicosis the iodin which is introduced artificially is excreted in lesser quantity and more slowly in the urine, without the amount of iodin in the thyroid gland being increased. This is not the case in normal glands and in ordinary goiter.

Treatment.—The treatment is partly symptomatic and partly causal. In accordance with the innumerable symptoms, the former calls for a great many different drugs, but, as a rule, has only a relative value, because as one symptom is relieved another symptom is increased. Symptomatic treatment is, therefore, being relegated more and more to the backgrouund.

Internal causal treatment consists in avoiding or diminishing injurious influences and, on the other hand, in modifying the function of the thyroid gland.

The *first* indication is met, above all, by rest, fresh air, and cold water, with bromids and phosphorus preparations, strophanthus, validol, digalen, and general regulation of the patient's mode of life.

The function of the thyroid gland may be influenced (*a*) by faradization and galvanization, which often act very favorably by diminishing the vascularity; (*b*) by means of the *x*-rays, which, however, have but little effect and are sometimes contra-indicated on account of their influence on the skin.

(*c*) By means of serum obtained from thyreodectomized animals, which acts equally well whether given by the mouth or subcutaneously. It has a distinct influence on the symptoms and but little effect on the thyroid gland. The effect lasts only as long as the serum is given, and it does not prove successful in every case.

(*d*) Rodagen, the pulverized milk of thyreodectomized animals or the milk itself, is less efficacious than the serum and has but a temporary action.

(*e*) *Cytotoxic serum* was employed by Kocher as early as 1902, and more extensively and in various forms by Beebe and Rogers since 1905. Some of Beebe and Rogers' results have been extraordinarily gratifying, but they are by no means always secured. Further clinical and experimental work is still going on. As the serum is relatively difficult to prepare and by no means uniform, it has not been employed very extensively.

(*f*) Injections of iodin and iodoform into the gland may produce a distinct effect, but their administration is attended by some risk, and they usually act only by producing a sclerosis of the tissue. Abbe has reported success in reducing enlarged thyroids by inserting the strongest radium sealed in small glass tubes into the tumors (10 cgms. of 300,000 strength for twenty-four hours; 60 mgs. of 1,800,000 strength for eight hours).

Surgical Treatment.—To say that this is still the best is not enough. It has proved itself superior to any other form of treatment. It attacks the organ which is instrumental in producing the toxicosis, namely, the thyroid gland. Kocher's thyreodectomies for Basedow's disease number 200 cases, with a mortality of 4.5 per cent. and 85 per cent. of recoveries. The operation is indicated in all cases that do not present degeneration of the heart muscle, with irregular pulse, low blood pressure, or periodical attacks of delirium cordis. In any severe case it is advisable to perform one or two preliminary ligations of the superior thyroid artery. The remaining steps of the operation are determined by the course of the disease and by the size and condition of the thyroid gland; in pronounced cases unilateral excision of the larger or rather the more vascular half of the gland, including if possible the isthmus and pyramidal process, is the safest procedure. In early cases that still present exquisite *struma vasculosa* equally good results may be obtained by ligating the trunks of two or three arteries of the thyroid gland. Removal of more than half the gland should not be considered except in rare cases of very large glands. Removal of the second

inferior horn requires the greatest care on account of the parathyroid glands, and should, if possible, be avoided. The operation is much more difficult in Basedow's disease than in cases of ordinary goiter on account of the great vascularity, the friability of the vessels, the adherence of the external thyroid capsule, and the brittleness of the gland tissue, particularly in cases of diffuse papillomatous or inflamed thyroid gland. The operation should be performed only by a surgeon who has had experience and practice in removal of the thyroid gland. The most painstaking control of the bleeding and the avoidance of antiseptics and of other toxic substances are absolute prerequisites for the success of the operation. The postoperative symptoms, which are severe enough in themselves, on account of the psychic excitement and the effect of the anesthetic, when one has been employed, must not be increased by wound complications, especially hemorrhage. For this reason, primary ligation of one or two arteries, which requires very little time and is regularly followed by improvement, offers the best means of avoiding complications during the main operation. Most writers caution the operator strongly to handle the goiter as gently as possible during operation lest the juice be expressed and absorbed and so produce acute thyroidism. While gentleness is always desirable it is doubtful whether rough handling is the cause of such acute attacks. If it were, the toxic effects ought immediately to follow the operation, whereas not seldom they do not begin for from twelve to twenty-four hours after operation. Weir Mitchell has also had such goiters vigorously massaged without any injurious results and also without any benefit.

Operations on the sympathetic nerve have been given up, since it has been demonstrated that in the majority of the cases these operations are not productive of the slightest good.

The results of the operative treatment are almost uniformly good. Kocher has shown that success is proportionate to the degree to which the hypervascularized thyroid tissue is reduced by ligation of arteries or partial removal of the gland. The postoperative phenomena in the form of an increase in the toxic symptoms are pronounced only after complicated operation (resection) and when a general anesthetic has been given. The greater the care employed in operations and the smaller the quantity of blood lost, the milder will be the postoperative symptoms. The fever and increased pulse rate are the results of severe reaction on the part of the organism, which is shown by the regular subsidence of the fever after the drainage and the sutures have been removed.

The toxic symptoms are followed by the improvement (in uncomplicated cases and in cases operated on without an anesthetic after a few hours), which manifests itself in marked restfulness and in a quiet expression of the eyes. On the following day, and still more on the succeeding days, the pulse rate diminishes and all the symptoms improve. The subsequent improvement depends on the degree and duration of the disease. In early cases, where there has not been insuffi-

ciency of the heart, complete recovery with subsidence of all the symptoms is the result of operative treatment. Hence, early operation is the best treatment of thyrotoxicosis.

GOITER (STRUMA).

The term goiter is used to designate a disease of the thyroid gland which occurs in that structure only and is, therefore, specific to the gland.

The classification of goiter always presented great difficulties because of the impossibility of bringing the different clinical and anatomic forms into harmony, *e. g.*, the vascularity of the gland, which has such enormous clinical importance, while pathologically it is quite secondary.

First of all, we distinguish enlargements in which the disease affects the entire gland—*diffuse goiter*—or only part of the gland—*nodular goiter*.

Diffuse Goiter (*Struma Diffusa*).—In diffuse goiter we distinguish a number of different forms according to their histologic characters, depending on the prevalence of one or the other element of the normal gland.

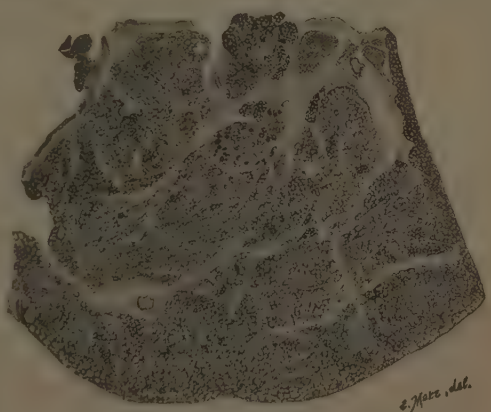


FIG. 216.—SECTION OF FOLLICULAR GOITER.
Genuine hypertrophy of the thyroid gland. (Magnified.)

(1) *Hypertrophic follicular goiter* (*Struma hypertrophica follicularis*) is an enlargement of the thyroid gland due to increase of all the gland elements, *i. e.*, new formation of follicles and corresponding increase of epithelium, colloid, blood-vessels, and stroma. This is a genuine hypertrophy of the gland, and is really nothing but the primary stage of the two following forms:

(2) *Struma Parenchymatosa.*—The enlargement is produced chiefly by increase in the number and size of the epithelial cells; the follicles become irregularly branched; the vessels are dilated, and the colloid is at least relatively diminished. The surface of the tumor in this form exhibits somewhat coarser lobulation than is seen in the normal gland. Owing to the dilatation of the blood-vessels the consistency is softer; the cut surface, when recent, is dark purple in color; the lobules are visible, but not to the same degree as in the normal gland, and much less so than in follicular goiter. The delicate granulation is wanting. The tissue is less transparent and the amount of colloid, which is thinner than in the normal gland, exuding from the

tissue is diminished. This form of struma is rare, and occurs practically only in combination with struma follicularis or colloides.

(3) *Diffuse Colloid Goiter* (*Struma Colloides Diffusa*).—The enlargement is chiefly due to enlargement of the follicles, which in turn is caused by an increase of the colloid material. The latter is more tingible, contains fewer vacuoles, and completely fills the follicles; the cells are lower; the vessels in the main not overfilled, but contain rather less blood than normal; the surface of the tumor is coarsely lobulated and the lobules are more prominent; the consistency is dense and harder than in the two varieties just described, although this, of course, depends on the vascularity; the color of the recently cut surface is more yellowish red; the transparency is increased; and the cut surface exudes thick, extremely tenacious colloid material in considerable quantity. This

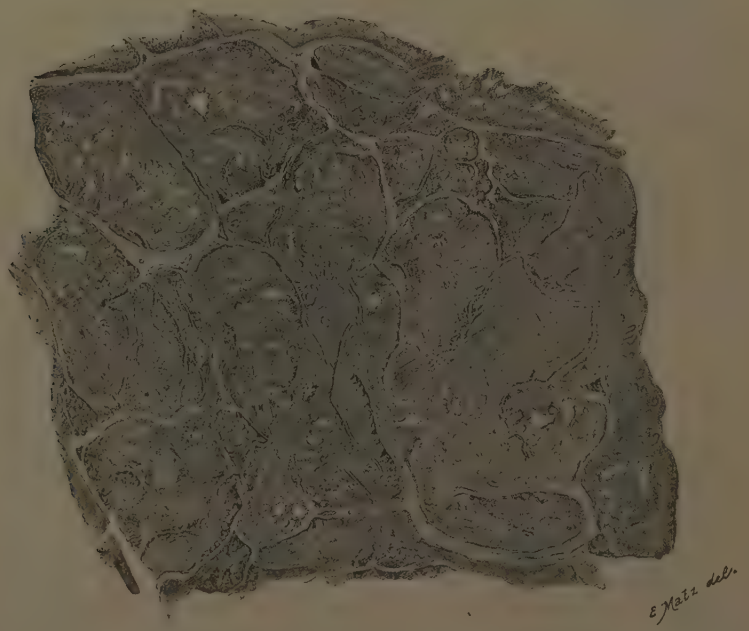


FIG. 217.—SECTION OF PARENCHYMATOUS AND DIFFUSE ADENOMATOUS GOITER. (Magnified.)

form of diffuse goiter is by far the most frequent. Intermediate forms between the above-mentioned types of diffuse goiter are encountered; since a follicular goiter may be converted into a parenchymatous or colloid tumor, and, on the other hand, either of these varieties may change to one or the other type. For this reason it is difficult to find a correct name for every variety, which also explains the want of uniformity in the nomenclature. It is, nevertheless, important for therapeutic reasons to distinguish between the different forms, and the characteristic points of each will therefore be given in greater detail under the head of Symptomatology and Diagnosis.

(4) *Diffuse Vascular Goiter* (*Struma Vasculosa Diffusa*).—When in one of the above-mentioned three varieties of goiter the vascular changes are most prominent, and the blood-vessels, particularly the trunks of the arteries, are increased in volume, the goiter may present clinical

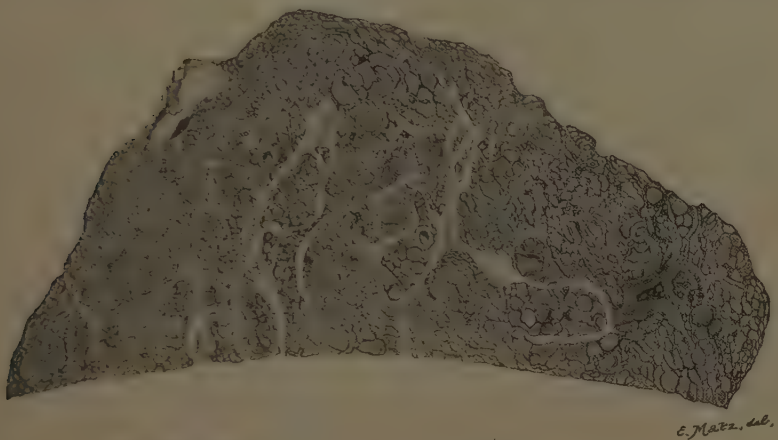


FIG. 218.—SECTION OF DIFFUSE COLLOID GOITER. (Magnified.)

symptoms which we regard as vascular phenomena, and the term struma vasculosa diffusa is accordingly employed. The pathologic diagnosis of struma vasculosa is only exceptionally possible unless the tissue is injected.

(5) *Diffuse Fibrous Goiter* (*Struma Fibrosa Diffusa*).—This cannot really be considered a special form of struma, and is more important from the pathologic than from the clinical standpoint, because the alteration is usually secondary. The condition is rare. As a result of inflammation and secondary development of connective tissue one of the above-mentioned varieties of diffuse goiter may be converted into a fibrous goiter; although it is hardly necessary to say that the connective-tissue change does not involve the entire gland.

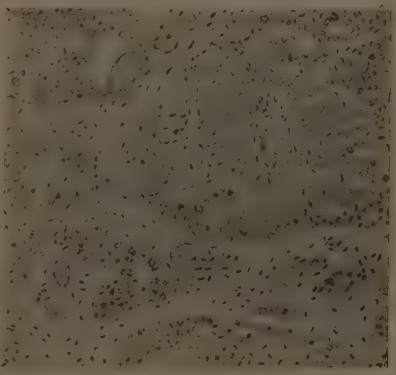


FIG. 219.—DIFFUSE FIBROUS GOITER. FROM A CRETIN. (Leitz obj. 5.)

(6) *Struma Adenomatosa Recurrens*.—This is a variety of diffuse goiter characterized chiefly by the new formation of small follicles and resembling adenoma, which otherwise occurs only as circumscribed nodules. Many cases properly belong among the malignant growths, and the term adenoma malignum is therefore also employed. These goiters are very rare.

Nodular Goiter (*Struma Nodosa seu Circumscripta*).—That form of the specific disease of the thyroid gland which develops only in one or more portions of the gland (circumscribed proliferation of gland tissue: cells, stroma, colloid). The parts that are not diseased are only secondarily affected, if at all. Most of the forms of goiter which belong to this group can be easily subdivided. The changes are analogous to those which occur in diffuse goiter:

(1) Circumscribed new formation of follicles in which the increase in the number of the follicles is the most prominent feature; it usually occurs only in the initial stage.

(2) Circumscribed new formation in which the increase of colloid predominates; this is by far the most common form.

(3) Circumscribed new formation in which the proliferation of the cells and cell-tubes predominates.

The most important characteristic of nodular goiter, as compared with diffuse goiter, is the absence of regularity in the subdivision and arrangement of the tumor, which characterizes struma diffusa as a hyperplasia of the normal gland. The proliferation of the gland elements in struma nodosa is irregular and unequal.

The second characteristic of nodular goiter is a tendency to degeneration of the tumor elements, in which specific processes, such as colloid degeneration and gelatinous degeneration, may take place along with hyaline, fatty, and calcareous metamorphoses. The degeneration depends in part on the effect of excessive local proliferation on the neighboring tissue, and chiefly on vascular changes and their consequences; hemorrhage and the subsequent changes that take place in the effused blood.

The special form of goiter varies according as one or the other form of degeneration predominates. It is evident, therefore, that the great majority of nodular tumors represent a combination of the various forms of goiter and are designated according to the predominant alteration, or the alteration which has attained special development in one or more nodules.

In rarer cases nodular goiter consists of a *single isolated nodule.* A single nodule is most frequent in the rapidly degenerating forms in which several neighboring lobules undergo proliferation and usually, as a result of hemorrhage, accompanied by destruction of the specific gland elements, form a unilocular or multilocular cyst, a gelatinous, hyaline, or India-rubber nodule. Rapid growth is also relatively common in cases of isolated adenoma nodules.

In the great majority of cases isolated nodules are found in the lower horn of one of the lateral lobes. The presence of an isolated nodule in the isthmus is relatively frequent, and this condition will be specially discussed in the section on Operative Treatment, under the name of Struma mediana. In the upper horn isolated nodules are much more rare, and they are not often found in the pyramidal process. As isolated nodules usually grow rapidly and, owing to the secondary degeneration which is frequently present, resist internal treatment, they often attain a

considerable size and cause pressure atrophy of the gland tissue in the neighborhood. They are most accessible to operation and, as in almost every instance there is a remainder of healthy tissue, yield the best operative results.

Multiple nodular goiter is not so prone to undergo degeneration and grows less rapidly than a single nodule. When the nodules do degenerate, they increase in size. In almost every case some amount of normal tissue or, more rarely, hypertrophied gland tissue, is found near the nodule, particularly in the marginal portions of the gland, and again, the superior horns of the lateral lobes, and the posterior circumference nearest the trachea are the parts which preferably remain normal. Less frequently islands of normal tissue are found. The normal tissue is often compressed and its function may be impaired for that reason.

The *conversion of diffuse goiter into nodular goiter* occurs only in the colloid variety of diffuse goiter. When in this variety individual follicles become abnormally filled with colloid material, the epithelial lining which forms the wall of the follicle may be unable to resist the pressure, and a large follicle or colloid cyst results. At first these cysts appear as the so-called colloid pearls in the cross-section of the struma. If the process repeats itself, large collections of colloid material may form and give the impression of nodules, thus lending to the tumor the appearance of struma nodosa. Noteworthy and characteristic features in this variety are the small tendency to undergo degeneration and the absence of hemorrhages, which, as has been mentioned, is characteristic of genuine struma nodosa. These tumors represent the later stages of struma colloides diffusa.

FIG. 220.—DIFFUSE GOITER.

Position of the Goiter and Relation to Surrounding Structures.—The goiter, unless very much enlarged, occupies the position of the normal gland, and in that case has no material influence on the surrounding parts. This is the case particularly in **diffuse goiter,** which, in the main, retains the shape of the normal gland. If the goiter becomes very much enlarged, the superior horns enlarge upward on the lateral wall of the pharynx and extend as far up as the plates of the thyroid cartilage, the large horns of the hyoid bone, and the angle of the jaw, underneath the sternohyoid, sternothyroid, and omohyoid muscles, which are elevated, and at the anterior border, and underneath the sternocleidomastoids, in front of the large vessels of the neck. The inferior horns enlarge downward alongside, and in front of the

trachea and in front of the vessels, behind the sternohyoid, sternothyroid, and sternocleidomastoid muscles and their insertions on the clavicle and manubrium, through the superior opening of the thorax. Laterally, the enlarged gland develops underneath the sternothyroid and omohyoid muscles, which are raised, between the scaleni and sternocleidomastoid muscles, carrying the large vessels backward and outward. In front, the two lateral lobes approach each other over the isthmus until they come in contact and cover the trachea in front and along its entire extent. More frequently the isthmus enlarges to the same extent as the lobes, both in width and in thickness, causing elevation and separation of the muscles in front. The processus pyramidalis enlarges chiefly in length, its thickness being but little increased. Displacement of the trachea and esophagus takes place only when one side of the gland enlarges much more than the other. In that case the lumen of the trachea may be altered, particularly if the isthmus is not greatly involved; but the compression of the trachea is never severe. Hence *dyspnea* is relatively rare in diffuse goiter; often there is dyspnea on exertion only. For similar reasons *dysphagia* from pressure on the esophagus does not occur except when retrotracheal or retro-esophageal collections of gland tissue have developed. Marked displacement of the vessels takes place only when the goiter is very large; on the other hand, goiter of this kind produces symptoms of pressure on the large vessels of the neck, partly because the tumor presses on the vessels on both sides of the neck along its entire extent and partly because diffuse goiter, with the exception of the simple colloidal form, constantly changes its volume in accordance with the changes in its vascularity, so that the circulation cannot adapt itself to the new pressure conditions. Certain important symptoms of the follicular and parenchymatous forms of diffuse goiter, and particularly of the vascular forms, namely, *congestion* and severe circulatory disturbances in the brain, causing vertigo, headache, and the like, are produced by this intermittent compression of the vessels. On the other hand, *venous congestion* with dilatation of the superficial veins is rare in diffuse struma because the compression is not severe and only temporary. The nerves in the immediate neighborhood are very rarely affected by displacement or compression in diffuse goiter. In most cases the enlargement of the thyroid affects both lateral lobes, more rarely one lobe only or one lobe more than its fellow.

In contradistinction to the diffuse form, **nodular goiter** (*Struma nodosa*), when the enlargement is considerable, occupies a different position and much more frequently exerts a marked influence on the surrounding parts. The secondary effects depend not only on the position but also on the size and shape of the tumor. The effect on the surrounding structures is different when (1) instead of a single uniformly growing nodule, several nodules are formed and enlarge unequally; (2) when the position of the gland itself is altered and a goiter develops in the abnormally situated gland.

1. *When a nodule develops on one side of the neck* pressure is exerted on

the surrounding parts in the following manner: *Posteriorly* there is no compression because the gland lies on the deep muscles of the neck, which in turn rest upon the transverse processes of the vertebræ. *In front* the muscles and fasciæ are elevated, sooner or later, according to their strength, forced apart, and gradually flattened by pressure and atrophy. The goiter becomes more and more superficial and, owing to the elasticity of the skin and the action of gravity, may ultimately grow down over the thorax in the form of struma pendula. The same thing takes place laterally except that the prominence of the goiter in this direction is less pronounced on account of the thickness of the muscular layer. At the posterior portion of the periphery the vessels, which are connected with the external goiter capsule, are displaced outward in proportion to the distention of the capsule, so that in pronounced cases the carotid is felt in the external posterior

FIG. 221.—NODULAR GOITER.

FIG. 222.—LARGE PENDULOUS GOITER.

portion of the tumor underneath the skin and along the outer border of the sternocleidomastoid muscle. This is a characteristic feature of goiter (Kocher).

Along with the blood-vessels the pneumogastric nerve also is displaced. It is well known that compression of the artery may also produce symptoms of pressure on the pneumogastric, namely, slowing of the pulse, dyspnea, and syncope. Similar pressure and displacement of the trunk of the sympathetic nerve may take place.

In the direction *toward the median line* the pressure first acts upon the *trachea* and *larynx*, thereby producing one of the most *important* and *frequent* symptoms, frequently because the growing goiter meets with muscular resistance in other directions. The effect of the pressure in this direction depends chiefly on whether the trachea can be displaced or not, that is, on the presence or absence of goiter on the other

side of the neck. If the other side is not enlarged, the trachea yields to the pressure in two ways according to its points of fixation:

1. The trachea may assume a curved direction with the convexity toward the sound side, in which case the wall of the trachea which is in apposition with the tumor bulges more than the other.

2. The trachea and larynx rotate about their long axes. The posterior circumference rotates around the anterior as an axis because the latter is fixed above by the thyroid ligament and the hyoid bone, while the posterior is free. The posterior periphery of the trachea and larynx is therefore rotated away from the compressing goiter. This point may be of importance in the diagnosis (Kocher). If the goiter is bilateral the larger tumor may cause lateral displacement of the trachea with the smaller tumor of the other side; or the walls of the

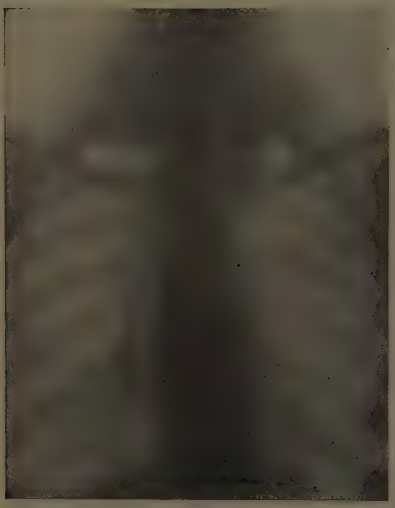


FIG. 223.—SKIAGRAM SHOWING DISPLACEMENT AND UNILATERAL COMPRESSION OF THE TRACHEA. (Pfeiffer.)

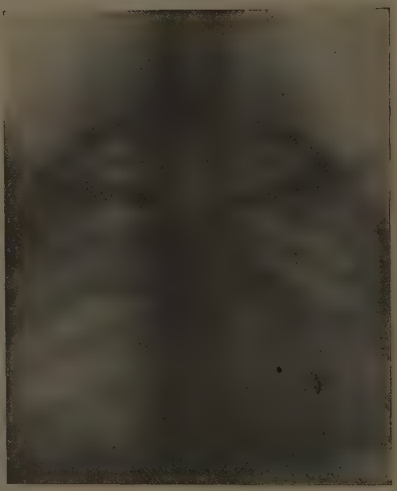


FIG. 224.—SKIAGRAM SHOWING BILATERAL COMPRESSION OF TRACHEA. (Pfeiffer.)

trachea may be compressed from both sides, bending inward the lateral walls of the trachea, so as to approximate them in the median line. If the pressure of the bilateral goiter is exerted at different levels on the two sides, the trachea may assume an S shape and suffer a spiral rotation.

Backward and *inward* the tumor, particularly when on the left side, presses upon the lateral wall of the esophagus and pharynx. But as the anterior and posterior walls of the esophagus are normally in contact, the effects of the pressure are not marked unless portions of the goiter are present between the trachea and esophagus, or behind the latter, that is to say, when they exert pressure either on the anterior or on the posterior wall of the tube. This occasionally happens in diffuse goiter and in cases of struma nodosa when there are deep-seated

nodules, because the esophagus at a deeper level is placed more to the left.

Inward and *backward* pressure on the inferior laryngeal nerve or recurrent nerve of the pneumogastric is possible. This is rare, however, in ordinary cases of goiter. It occurs only when the nerve has been forced out of the groove between the trachea and esophagus by the goiter and lies on the tumor. The nerve is lodged in the external goiter capsule, and outward displacement of the nerve practically occurs only when the capsule is the seat of inflammatory adhesions or malignant proliferation.

2. *A nodule in the superior horn of the gland* grows upward and outward because it finds in that direction a *locus minoris resistentiæ* between

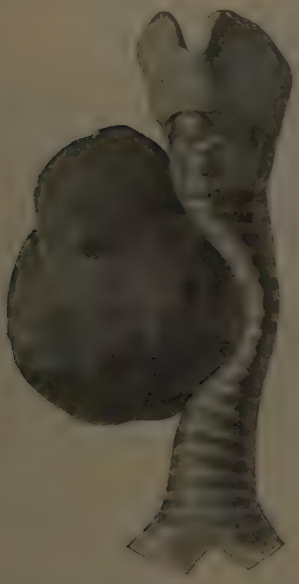


FIG. 225.—SCHEMATIC REPRESENTATION OF COMPRESSION AND ROTATION OF THE TRACHEA FROM UNILATERAL GOITER.

FIG. 226.—SCHEMATIC REPRESENTATION OF COMPRESSION OF THE TRACHEA FROM BILATERAL GOITER.

The pressure is exerted at similar levels on the two sides. The isthmus is omitted.

the omohyoid and sternocleidomastoid muscles. The tumor grows outward underneath the angle of the jaw and becomes superficial (see Fig. 228).

3. *A nodule developing in the inferior horn* encounters greater resistance in the surrounding parts. Such a nodule may grow toward the median line and appear on the surface in the jugulum or episternal notch after forcing the median muscles apart, the trachea being at the same time displaced laterally along with the gland or goiter of the other side of the neck. A nodule of this kind may be designated *struma mediana* and, particularly when it grows downward behind the manubrium, may produce direct anterior pressure on the trachea and marked dyspnea. Or—and this is more frequent—it may grow behind the

sternohyoid, sternothyroid, and sternocleidomastoid muscles, displacing the trachea backward and to the other side, and extend into the opening of the thorax in the form of *struma profunda* and *intrathoracica*. The extension of such a tumor into the thorax is aided by two factors. In the first place, the thyroid gland moves downward during inspiration and is, so to speak, sucked into the thorax during deep inspiration; in the second place, the gland is forced into the thorax when the head is inclined forward. Struma intrathoracica is accordingly observed frequently in people who are forced to breathe deeply and perform much of their work with their heads bowed (clergymen, army officers, government officials, etc.). At first a deep goiter moves up and down

FIG. 227.—SCHEMATIC REPRESENTATION OF COMPRESSION AND ROTATION OF THE TRACHEA FROM BILATERAL GOITER.

The pressure is exerted at different levels on the two sides. The isthmus is omitted.

FIG. 228.—GOITER DEVELOPING IN THE UPPER HORN OF THE THYROID GLAND.

with every respiration—*struma profunda*. But when it extends underneath the first rib, having passed the narrowest portion of the thorax, it finds more room and the goiter continues to grow. A constriction is formed at the level of the upper opening of the thorax. When the goiter has reached this stage it no longer escapes from the thorax except during forced respiration, during deglutition, and especially during cough—*goitre plongeant, diving* or *plunging goiter*. If the enlargement continues, the tumor can no longer be forced out of the upper thoracic aperture even by vigorous straining and coughing—*struma intrathoracica*. During deglutition and when the patient coughs the palpating finger in the episternal notch barely feels the impact of the rising goiter.

With the fluoroscope the tumor can be seen to rise during deglutition. A skiagraph shows a distinct shadow with a characteristic round border

FIG. 229.—MEDIAN GOITER PARTIALLY INTRATHORACIC.

with convexity forward. An intrathoracic goiter may attain enormous dimensions. It usually grows more on one side, depending on the

FIG. 230.—PHLEBECTASIA WITH PROFOUND GOITER.

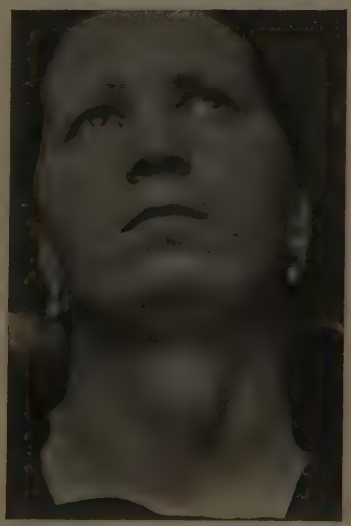


FIG. 231.—GOITER DEVELOPING IN THE PYRAMIDAL PROCESS. (STRUMA PYRAMIDALIS.)

starting-point, and rather more in front and to one side of the trachea, extending downward into the anterior mediastinum, where it is usually placed in front of, rarely behind, the innominate artery and arch of the aorta.

4. *A nodule developing in the isthmus*, or *true struma mediana*, usually grows directly outward, forcing the straight muscles of the neck asunder. Or it may grow more downward behind the manubrium and in that way cause direct compression of the trachea, anteriorly. The goiter is rarely confined to the isthmus alone. In such a case the growth of the goiter may be such that the lateral lobes merely appear attached to the struma like a pair of ears. Operation in these cases in general, and particularly in the case of struma mediana, is difficult.

5. *Struma Pyramidalis.*—Very rarely a nodule develops in the pyramidal process of the gland. The tumor in this case is also situated in the median line, but higher, in front of the trachea, cricoid, and larynx. It is quite superficial.

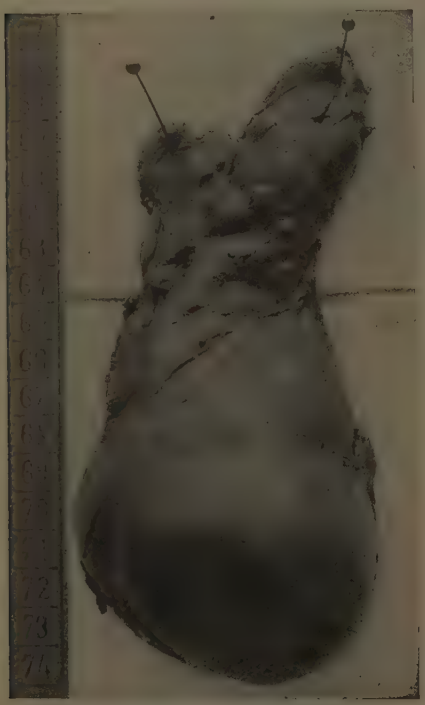


FIG. 232.—INTRATHORACIC GOITER.
The constriction due to pressure upon the clavicle and the manubrium of the sternum is clearly shown.

6. *The thyroid gland itself may occupy an abnormal position* and with it the goiter which develops in the gland. By far the most frequent anomaly is a *deep position* of the gland (thyreoptosis, Kocher). In short-necked individuals and when the thorax is very much arched, the gland is deeply placed. As the trachea is shorter and the larynx in pronounced cases is only a finger's breadth above the episternal notch the greater part of the thyroid gland is intrathoracic. This constitutes thyreoptosis with laryngoptosis. Thyreoptosis without laryngoptosis is very rare. In thyreoptosis the developing goiter at once becomes a struma profunda or intrathoracica. The pressure on the vessels in these cases is especially great and causes marked congestion, whereas in unilateral struma profunda or intrathoracica compression of the trachea is more prominent.

Thyreoptosis may also go on to the production of struma profunda or intrathoracica diffusa. These cases offer great operative difficulties.

In a rare form of abnormal position of the thyroid gland, which really belongs to the embryonal malformations, the trachea or esophagus is completely surrounded by the superior horns of the gland. It is in this type of gland that the circular or *retrotracheal* and *retro-esophageal* goiters par excellence are observed.

Diagnosis and Symptoms of Goiter.—The diagnosis of goiter is often suggested by:

1. The above-described position of the tumor, particularly in regions where goiter occurs endemically. The position is determined by *inspection* and *palpation* because the goiter cannot always be recognized by the former method alone. This applies not only to struma intrathoracica or profunda, but also to the diffuse forms, especially the soft follicular and parenchymatous goiters, and the latter particularly when the tumor is not large and the muscles of the neck are strongly developed. It is in just such cases of hypertrophy that the patients are often unaware of the existence of a goiter and the functional symptoms, which chiefly attract attention, are referred to a great variety of causes and often treated accordingly.

2. *The up-and-down movement of the tumor during deep respiration and especially during deglutition* is characteristic, and is due to the close connection between the external goiter capsule and the trachea and esophagus. When the goiter is visible this movement can be seen at some distance, and is always readily palpable—a point of special importance in cases where the goiter can only be felt and not seen. When the goiter is very large, and in cases of firmly impacted struma profunda or intrathoracica, the movement is difficult to demonstrate. It may be absent when there are numerous inflammatory adhesions or the tumor is the seat of malignant degeneration.

Movement during Cough.—In cases in which it is difficult to feel the goiter the examiner must never neglect to have the patient cough, as this renders the tumor much more distinctly visible and palpable. Diving or plunging (retrosternal) goiter often can be seen or felt only when the patient coughs, and intrathoracic tumors are often rendered much more distinctly palpable by the act.

3. *Relations Between the Tumor and the Gland.*—In diffuse goiter the shape of the normal gland can often be recognized at once by inspection and palpation. In struma nodosa the connection with the normal portion of the gland must be determined.

4. *Passive Mobility of the Goiter.*—A goiter can be moved about freely in the surrounding tissue, the mobility being greater in the lateral direction than up and down. Unless the goiter is inflamed or malignant it can also be slightly moved on the trachea, but can never be entirely separated from it.

5. *Percussion and Auscultation.*—These methods are of considerable value in the diagnosis of struma profunda and intrathoracica. The characteristic dulness, sometimes moderate and sometimes absolute, with a rounded lower border and beginning at the superior aperture of the thorax, is practically always present. Percussion and auscultation of the larynx and trachea yield dulness on the side of the goiter and diminished tracheal breathing (Kocher); an important diagnostic point in struma intrathoracica.

6. *Relation to the Blood-vessels.*—An important diagnostic point is the relation of the tumor to the vessels, particularly the superior thyroid artery and the great vessels of the neck.

Symptoms.—The symptoms of goiter are caused in part by the

presence of the tumor—*mechanical* and *physical symptoms*—and in part by the effect of the tumor on the structure of the gland—*functional symptoms.*

Mechanical Symptoms.—First of all, there is dyspnea. We distinguish (1) Dyspnea produced by pressure on the trachea, by far the most frequent form; (2) dyspnea produced secondarily by pressure on the blood-vessels and consequent disturbance of the circulation; and (3) dyspnea due to pressure on the recurrent nerve and paralysis of the laryngeal muscles, which is very rare in ordinary goiter. The manner in which the trachea is compressed and displaced has been described. The dyspnea may be constant or paroxysmal. It is increased by exertion. In the beginning it is present only during exertion. It is increased whenever there is a greater need of air. When the lumen of the trachea is greatly narrowed, especially when the pressure is circumscribed and unilateral, loud whistling inspiration and expiration result, the characteristic so-called *tracheal stridor.* When the trachea is greatly constricted, as above described, certain positions of the head causing complete closure of the lumen of the trachea, sudden pressure from without, or sudden exertion when the above-mentioned influences become operative, may produce attacks of asphyxia. This is particularly apt to occur when there is laryngeal or tracheal catarrh, which, owing to the diminution in the lumen of the trachea, is very apt to become chronic.

In the examination of a goiter it is important to note the influence on the respiration of pressure applied to different portions of the tumor. In this way that portion of the goiter which exerts the greatest pressure can usually be recognized (Kocher). In the case of large goiters which cause considerable displacement of the trachea it is found that pressure on the sound side produces dyspnea of greater intensity or brings it on more quickly than pressure on the diseased side. Sometimes very slight pressure on the sound side suffices to produce complete occlusion of the trachea. In such cases swallowing the wrong way, an attack of violent cough, or a hemorrhage into the goiter may be followed by sudden death from asphyxia.

Symptoms Caused by Injury of the Nerves.—In ordinary goiter, actual injury to the recurrent branch of the pneumogastric nerve which is followed by permanent hoarseness is quite exceptional. Temporary hoarseness, on the other hand, is not infrequent and, as a rule, depends on obstinate catarrh of the larynx or excessive use of the voice, as among army officers, riding masters, clergymen, teachers and singers.

Isolated injuries of the fibers or branches of the recurrent laryngeal are rare also; posticus and transversus paralyses occur in isolated lesions of the posterior branch of the nerve, and are practically observed only in retrotracheal goiter. The paralysis produced by partial injury to the nerve causes a permanent hoarseness; while hoarseness due to unilateral total paralysis of the recurrent may disappear by the swinging over of the healthy vocal cord to the paralyzed cord. Singing, however,

is impossible in this condition. This restoration of the voice does not occur so long as the goiter which is responsible for the paralysis persists, but may occur after removal of the goiter, and also after a paralysis of the recurrent, caused by operation. Paralysis of the recurrent increases an already existing dyspnea, but in itself does not necessarily cause dyspnea unless posticus paralysis is produced. Whenever there are signs that the recurrent nerve is involved in a goiter, one should suspect inflammation or malignant change.

The *sympathetic nerve* is rarely affected in ordinary goiter. Both paralysis and irritation of the sympathetic are observed, but it is not always possible to determine whether the disturbances are due to mechanical or to functional causes. Its paralysis, in all probability, is due to mechanical causes. It chiefly affects the oculopupillary fibers, while irritation shows itself preferably in the vasomotor and secretory nerve-fibers. When the paralysis has existed for some time it is not influenced by operation on the goiter.

FIG. 233.—RIGHT SMYPATHETIC PARALYSIS DUE TO GOITER.

Symptoms Caused by Impairment of the Circulation.—The symptoms depend chiefly on venous stasis, which develops when the veins that drain the neck, head, and arms are compressed by the goiter. Congestion is more marked in bilateral goiter and attains its greatest intensity in the intrathoracic form. The stasis produces engorgement of the anterior and external jugular veins and of the venous plexuses of the thorax. It is always associated, particularly during exertion, and in severe cases with cyanosis, affecting chiefly the lips, the cheeks, and the tongue. In severe cases there is puffiness of the face and neck, which may go on to edema. If the goiter presses upon the innominate veins, cyanosis and edema develop in the arms. A characteristic symptom in this form of goiter is inability to raise the arms on account of the sudden return flow of the blood and the consequent increase in the stasis and dyspnea (Kocher). Pressure on the arteries manifests itself in congestions, headache, vertigo, and the like; but these symptoms, in part at least, may be due to the existing dyspnea.

Symptoms Referable to the Heart.—Disturbances of the heart's action, which are very frequent in goiter, assume grave importance from the fact that they may in themselves prove fatal, and they are so characteristic that the term "*goiter-heart*" is employed. There are

special varieties of goiter-heart which, although primarily caused by the goiter itself, depend secondarily on various pathologic conditions, which in turn are produced by the goiter.

(1) The *dyspneic goiter-heart* (Kocher), caused by the interference of the goiter with respiration, results from the sudden increase of pressure in the veins and consecutive dilatation of the right heart. Ordinary dyspnea has no material effect on the heart; it must be of a severe degree and associated with attacks of asphyxia. Dyspneic goiter-heart occurs almost exclusively with struma nodosa.

(2) *Goiter-heart Caused by Pressure on the Blood-vessels* (Rose).—This is the more frequent form. It is caused by increased pressure, especially in the venous system, usually beginning gradually and becoming permanent. The cardiac lesion consists in a relatively late moderate dilatation of both chambers and a relatively early occurrence of general circulatory disturbances. The condition occurs chiefly with nodular, but occasionally also with diffuse goiters.

(3) *The thyreotoxic goiter-heart* (Kraus and Kocher), which is most pronounced in Basedow's disease, is caused by functional disturbance. It occurs chiefly with diffuse, but also with nodular goiters. The manifestations are acceleration of the heart action and its effects on the size of the heart and on the blood-current; systolic murmur, especially at the base of the heart from increased velocity of the blood-current; dilatation of the heart, also, chiefly at the base; pulsus celer and its consequences; and increase in the blood-pressure, at least at first.

Symptoms Caused by Pressure on the Esophagus.—Rarely there is dysphagia, or merely a feeling of pressure during deglutition.

Pain.—Pain is never present in ordinary goiter. Tenderness indicates some inflammatory process. Suddenly developing goiters or, in other words, hemorrhages into the tumor, may cause pressure pain by distention of the tissues, but the pain is only temporary.

The symptoms of functional disturbance of the thyroid gland by the growth of the goiter may be deduced from what has been said under the head of function.

Diagnosis and Symptomatology of the Various Forms of Goiter.—*Struma diffusa follicularis*, or true hypertrophy of the thyroid gland, is not usually brought to the surgeon for treatment, because it can be cured by internal medication. For the diagnosis of *struma parenchymatosa diffusa* we depend on the soft, fleshy consistency, the lobulated surface of the tumor (the lobules being quite small), and the excessive development of the blood-vessels. Symptoms of beginning thyroid intoxication are usually present at the same time. Another important aid is obtained by noting the effect of iodin treatment, which often produces symptoms of thyroid intoxication, particularly when it is continued for a considerable length of time and the drug is given in large doses.

The diagnosis of *diffuse colloid goiter* is based on the granular appearance of the surface, which is marked in large lobules (called by the French, *mamelloné*), and the increase in the consistency, which becomes

tense or even hard and less elastic. Iodin does not cause diminution of diffuse colloid goiter.

The diagnosis of *both kinds of vascular diffuse goiter* is based chiefly on the dilatation of the blood-vessels, which can be demonstrated clinically; on the vascular murmurs heard over the blood-vessels; the expansive pulsation of the goiter; and the changes which take place in its volume and consistency.

If a diffuse goiter is of unusually firm or even hard consistency, one should first think of an inflammatory process or of malignant degeneration, particularly when the goiter is sensitive to pressure. The inflammation is not, however, due to bacterial causes. Occasionally the inflammation leads to great proliferation of connective tissue, which is responsible for the firm consistency of the tumor. We then have a transitional form between a vascular diffuse and a fibrous diffuse goiter.

The diagnosis of *diffuse fibrous goiter*, or connective-tissue atrophy of the hypertrophied gland tissue, is made partly by the consistency, which may be hard, and partly by the presence of symptoms of hypothyroidism. This form of goiter is not sensitive to pressure.

Nodular goiter can usually be distinguished from the diffuse form without any difficulty. In a case of nodular goiter the surgeon must first determine the following points:

(1) Whether any normal gland tissue still remains and, if so, its location.

(2) If this is not the case, (*a*) which part of the struma nodosa causes the most alarming symptoms, and (*b*) which part is still capable of functionating and which is not.

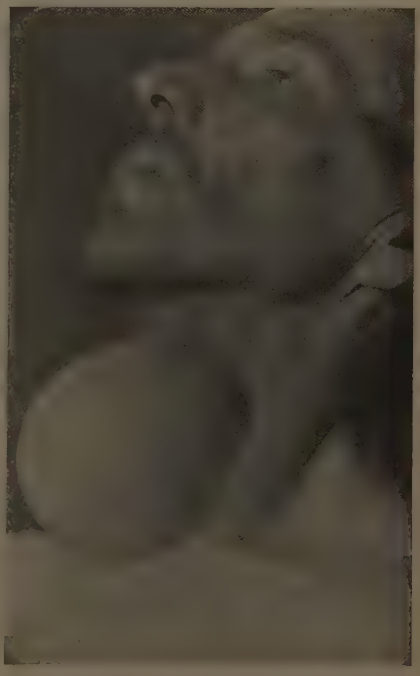


FIG. 234.—CYSTIC GOITER.

A goiter nodule is still capable of functionating if the tissue contains gland tubes with intact epithelium and a sufficient blood supply. It must, however, be remembered that although the functional capacity of strumous glands is relatively good, a much smaller portion of normal gland tissue than of diseased gland tissue is required to produce the same result. No precise directions in regard to the size of the piece to be left behind can be given (Kocher).

Cystic goiter is recognized by its circumscribed, circular, or oval shape, smooth surface, and often soft but always very elastic consistency.

The thicker the wall, the more tensely elastic is the cyst. Fluctuation can be detected with certainty only in very large cysts.

Blood cysts (*struma hæmorrhagica*) in which part of the blood is coagulated, are elastic also, but have a more doughy consistence than cystic goiter. Hemorrhage into the goiter produces an important and distinct form of struma, inasmuch as it may develop suddenly and produce sudden symptoms. One of the most conspicuous of these is the sudden sensitiveness to pressure from tension of the capsule. A peculiar consistence is presented when, after a hemorrhage into a cyst or a colloid nodule, the blood is converted into so-called India-rubber colloid, a fairly common occurrence. The nodules are usually large and of an elastic consistence, which, however, is due not to fluid, but to a solid mass resembling hard rubber.

Calcification is readily recognized by the hardness and the irregular surface which it produces in the tumor.

Colloid nodules vary according to the preponderance of the individual elements. The more colloid it contains, the more tensely elastic is the nodule, and if viscid colloid material predominates the nodule is firm. On the other hand, when more follicles with well-preserved epithelium are present in the colloid nodule, and the blood supply is abundant, the nodules are soft and elastic and the tissue retains its functional power to a greater degree.

Parenchymatous nodules possess a fairly uniform, smooth surface and soft consistence. The consistence is also proportionate to the vascularity, which, on the whole, is not very great. Parenchymatous nodules do not usually attain a very large size, not exceeding that of an egg or the fist. Rarely, several larger parenchymatous nodules, usually one large and several smaller ones, which are not palpable, may be found in normal or hypertrophied gland tissue; parenchymatous nodules are rarer than colloid nodules. The two varieties may be present at the same time.

In all the above-mentioned varieties of nodules the tissue may become atrophied and replaced by a more or less marked proliferation of connective tissue. The capsules of the individual nodules may be increased in thickness or, if connective tissue develops in the interior of the nodule also, they may become more firm. In addition the glandular tissue between the nodules and surrounding them may become atrophied from pressure and degenerate into connective tissue. Genuine struma fibrosa, however, or in other words, fibroma of the thyroid gland with tumor-like proliferation of the connective tissue, does not occur. Carcinoma of the thyroid gland may exhibit a secondary connective-tissue proliferation resembling scirrhus. We are convinced that goiters with multiple colloid nodules containing very thick colloid, and numerous small colloid cysts with relatively thick walls, have been diagnosed as fibrous goiters, a mistake which leads to absolutely erroneous views. Certain unusual changes that occur in goiter nodules, such as deposition of bone, hyaline, and amyloid degeneration, cannot be diagnosed with certainty.

Occurrence, Frequency, and Etiology of Goiter.—There is no country and possibly no single locality where goiter, in the widest sense of the term, has not been observed. It occurs, however, with special frequency in certain regions, and persons going to certain regions may at once develop goiter; while in other localities goiters have a tendency to disappear. Endemic goiter, in a great majority of the cases, is of the colloid variety. It is also certain that modern sanitation, particularly as to drinking water, and in a lesser degree, the increased intercourse between different parts of the world, have made the disease less common in the goiter regions.

We must distinguish between the causes which lead to the formation of goiter and those which favor the growth of the goiter. The growth of a goiter is more vigorous during periods when the functional activity of the thyroid gland is greatest, and is also increased by circulatory disturbances in the gland, which in turn may be the results of the goiter.

The growth of a goiter is influenced by puberty, menstruation, the menopause, pregnancy, venous stasis, or other circulatory disturbances in the gland, forward inclination of the head, the stress of school life and certain occupations (porters), impeded respiration and circulation by pressure from without or by some other disease, and finally, by abnormal position of the gland. In the main these causes are also responsible for the secondary changes that take place in goiter.

Of the factors that influence the growth of the goiter, some act on the gland as a whole, while others affect only part of the gland or one part more than another. Whether the real cause of goiter-formation always acts on the entire gland or only on part of it is not definitely known. The probabilities, however, are in favor of the former view, and a circumscribed growth may quite possibly depend on the factors mentioned above as influencing the growth of the goiter.

The general belief in regard to the actual cause of goiter-formation is the same now as it was fifty years ago—viz., some peculiarity of the drinking water derived from the soil through which it passes. There is no doubt also that drinking water is the chief source of iodin for the human organism, and that the thyroid gland takes up and elaborates the greater portion of this iodin as its specific function. It is, therefore, quite natural to attribute the development of goiter, which in itself merely represents a normal thyroid gland somewhat altered in respect to the number and quantity of its different constituents, to some change in that constituent of the drinking water which has a special affinity for the thyroid gland; in other words, the iodin. This change is probably more than a quantitative change, as appears from recent investigations, especially along chemical lines; but as yet we do not know how the iodin is combined in the different kinds of drinking water, or even whether under certain circumstances it may not be combined with organic constituents. It is obvious that the manner in which the iodin is combined must influence the gland itself in which the iodin must be converted into iodo-albumin, and it needs no special arguments to show that it must also influence absorption and especially secretion.

Recent histologic investigations (Langhans) have shown that in localities where goiter is endemic he follicles of the thyroid gland contain more colloid, especially more viscid colloid, and that the lymph-vessels contain less colloid than in places where goiter occurs sporadically only.

We, therefore, regard as the cause of goiter a change in the secretory or resorptive function of the thyroid gland, due to special chemical peculiarity of the iodin combinations. One can readily understand that this disturbance may manifest itself more in one part of the gland than in another, and may be especially favored by the occurrence of circulatory disturbances. On the other hand we have seen that even the normal thyroid gland may adapt itself functionally to new conditions, partly by virtue of the presence of imperfectly developed embryonal follicles and partly through changes that take place in the follicular epithelium and in the contents of the follicles. It is, therefore, clear that *functional irritants*, especially in glands which are prone to develop goiter on account of the presence of abnormal thyroidable material, also play an important etiologic rôle in the development of goiter. Moreover, the thyroid gland may become the seat of a form of tumor called *struma*, which is characterized by an *abnormal* proliferation of the glandular elements similar to tumor-formation in other organs. That functional irritants also may share in the etiology of these tumors is shown by the frequent occurrence of adenoma papilliferum diffusum in Basedow's disease. With regard to the remaining adenomata, their histology is as yet but little known; all may possibly belong to the epithelial form of malignant goiter, and are therefore exceedingly interesting from the etiologic viewpoint. From the investigations of Hitzig and Michaud they appear to develop by metastasis through some change in the completely developed epithelium.

Course and Prognosis of Goiter.—Goiter continues to increase practically indefinitely unless the disease is arrested or reduction of the tumor is brought about by change of climate or a change of diet. After the fiftieth year of life, however, the goiter often tends to diminish gradually, or at least to become arrested unless the presence of circulatory disturbances, inflammation, or malignant degeneration causes a continuance of the growth.

Functional disturbances due to the goiter may seriously affect the prognosis, both early in life and at a more advanced age, and they must always be taken into account in every case of goiter. The mechanical symptoms may favor disease in the various organs quite independently of the direct injury which they produce in these organs. In no case of goiter-formation should an absolutely favorable prognosis be given without careful thought. The dangers from goiter are increasing stenosis of the trachea, increasing impairment of the cardiac and pulmonary functions, hemorrhage into the growth, and malignant degeneration. Suitable internal medication, if applied early, may accomplish a great deal in a prophylactic sense. Timely operation on

a goiter is almost without danger, Kocher's mortality being only about 3 in 1000.

Treatment and Prophylaxis of Goiter.—The largest share of the treatment belongs to the internist, but it is through surgery and the experience gained from operative cases that our knowledge of the internal treatment of goiter has been enriched. The time has long passed when every goiter patient, without respect to person, was given iodin internally and externally, without choice of preparation or accuracy in dosage. Appropriate internal treatment must be based on accurate investigation of the goiter and the patient. It is of the greatest importance to determine whether and in what form and dosage iodin shall be administered, and whether the drug shall be combined with other remedies or therapeutic procedures. Space forbids a discussion of the internal treatment in this article.

Operative Treatment.—The indications for operative treatment are various. We long ago abandoned the belief that every goiter must first be treated with internal remedies and referred to the surgeon only if internal medication fails.

(1) Internal treatment is useless in struma nodosa with nodules in process of secondary degeneration. Degenerative nodules can also be recognized directly by the changes in their consistency. Thus, all colloidal degenerated nodules (struma gelatinosa), as well as fibrous, calcareous, hemorrhagic, and cystic nodular goiter, must be at once turned over for operative treatment.

(2) Diffuse colloidal tumors that have resisted several brief periods of iodin medication must be referred to the surgeon, especially if they have already given rise to functional disturbances.

(3) All goiters that cause pronounced pressure-symptoms must be treated by operation.

(4) The same is true of those which produce cardiac symptoms and (5) of goiters that are abnormally situated, especially struma profunda and intrathoracic, which are very dangerous if the tumor continues to grow.

(6) If a goiter develops suddenly and grows very rapidly, and if the shape and consistency are unusual, it must be treated by operation regardless of the patient's age.

(7) A goiter showing sensitiveness on pressure, especially if it causes spontaneous pain, must be referred to the surgeon.

The *contra-indications* to operation are: Respiratory and circulatory disturbances of long standing when due to the goiter, with secondary impairment of the vital functions, especially of the heart's action. Disturbances of the circulation, the heart's action, and the respiration due to concomitant diseases, such as obesity, fatty heart, myocarditis, or severe emphysema with bronchial and tracheal catarrh. Patients of this type must be kept under observation for a considerable period of time in order to determine: (1) Whether the symptoms are positively due to the goiter; (2) if such is the case, whether the heart, lungs, and kidneys can be sufficiently improved by preliminary treatment, with

special attention to the pulse, blood-pressure, and renal function, to render an operation safe.

Operative Treatment.—This may be by: (1) Excision (Kocher); (2) enucleation (Porta and Socin); (3) resection (Mikulicz); (4) combined methods; (5) exenteration (Kocher); or by (6) ligation of arteries (Wölfler).

The method of choice is *excision:* (1) Because it is the safest, both as regards the operation itself and the freedom from complications; (2) because it is most effective; (3) because it is less often followed by recurrence of the tumor, and very rarely by recurrence with symptoms.

Enucleation should be selected: (1) When the other half of the thyroid gland is atrophied or has been removed by previous operation; (2) in the presence of only a few isolated nodules in otherwise normal tissue; (3) when there is one large single nodule which has caused

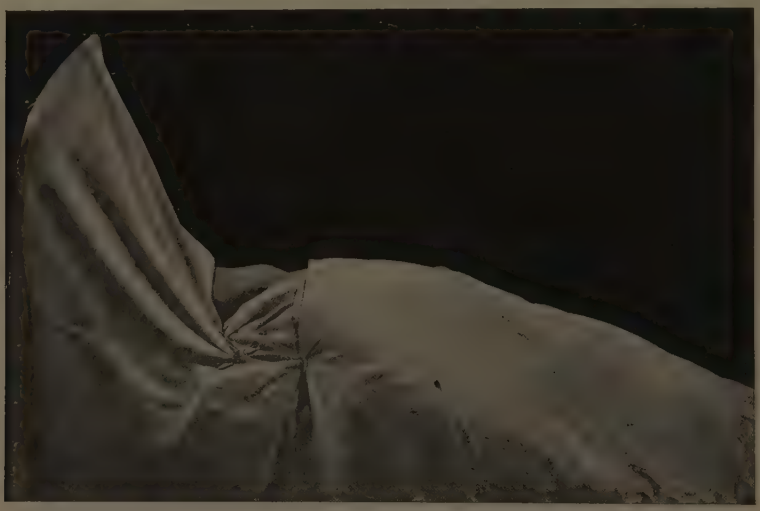


FIG. 235.—RECUMBENT POSITION OF THE GOITER PATIENT FOR OPERATION. Showing protection of the surrounding parts with sterilized cloths.

atrophy of the surrounding tissue, and it is to be assumed that but little normal and comparatively avascular tissue is present.

Resection should be considered in exceptional cases only, as in diffuse goiters, particularly when unilateral excision has already been performed or the tumor is very large in both inferior horns. The operation is always much more severe and attended with a greater loss of blood because, owing to the friability of the tissue, it is often very difficult to control the hemorrhage. Primary resection is absolutely contra-indicated in Basedow's disease.

The *combined* methods—enucleation and resection, enucleation and excision, resection and excision—are frequently employed instead of excision, particularly when it is desired to preserve certain portions of the gland; that is to say, when the functional capacity of the other half of the gland is in doubt.

Exenteration, or incision of the tumor and evacuation of its contents, is indicated in the presence of dense adhesions and in inflamed or malignant goiters when clean excision is impossible. It is especially indicated in intrathoracic goiters of this type, and particularly when there is danger of asphyxia, and prompt relief is imperative.

Ligation of the arteries of the thyroid gland is indicated in vascular goiters and is employed as a preliminary operation in Basedow's disease. In these cases the superior arteries are ligated. Ligation of the inferior thyroid artery is difficult and cannot be safely performed without first elevating the goiter. It is, therefore, in most cases combined with immediate excision. Ligation should be considered when it seems probable that it will be followed by a sufficient degree of involution and preservation of a portion of the gland substance appears essential.

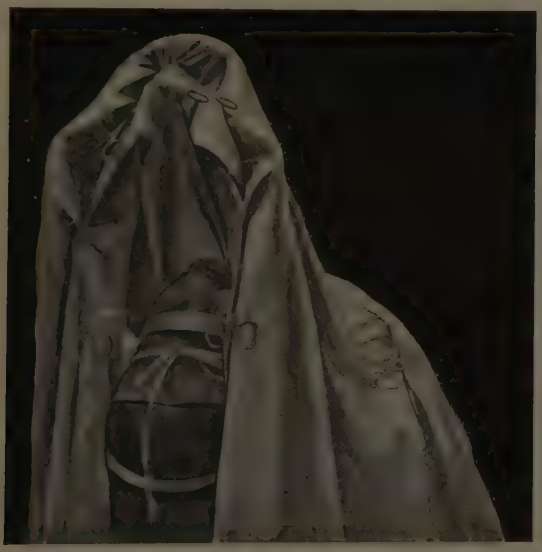


FIG. 236.—KOCHER'S SCREEN FOR PROTECTING THE FIELD OF OPERATION FROM THE MOUTH, NOSE, ETC.

Operative Technic.—*Position.*—The neck must be made as prominent as possible: over-extension of the head; dependent position of the thorax; isolation of the operative field by Kocher's method.

Anesthetic.—Local anesthesia with novocain or a 1 per cent. solution of cocain with adrenalin, or possibly infiltration anesthesia of the nervous cutaneous colli, usually suffices. General anesthesia should be avoided whenever possible. The special contra-indications to anesthesia are: stenosis of the trachea and cardiac and pulmonary complications.

Incision.—Kocher's incision is the best. Only in the case of very large goiters, extending high up into the neck, is it necessary to employ the angular incision with rounded angles above the cricoid cartilage. The next successive steps are division of the platysma and of the anterior and oblique jugular veins, followed by splitting of the median deep

fascia and division of the insertions of the sternohyoid, sternothyroid, and omohyoid, depending on the size of the goiter. The external goiter capsule is then stripped off by blunt dissection after securing the accessory veins, which are lodged in its outer surface.

Excision.—Delivery of the goiter (luxation by the Kocher method). Separate ligation of the trunks of both thyroid arteries. The veins are picked up and divided as near the tumor as possible, avoiding the recurrent nerve and both parathyroid glands. The isthmus where it lies on the trachea must be crushed, ligated *en masse*, and divided. If the recurrent nerve and the superior parathyroid glands are visible, clean excision of the goiter posteriorly should be made, every vessel being secured with hemostatic forceps. If the nerve and the parathyroids cannot be seen the goiter should be resected, leaving a piece of tissue with the posterior capsule. In the case of a larger nodule, enucleation may be performed posteriorly.

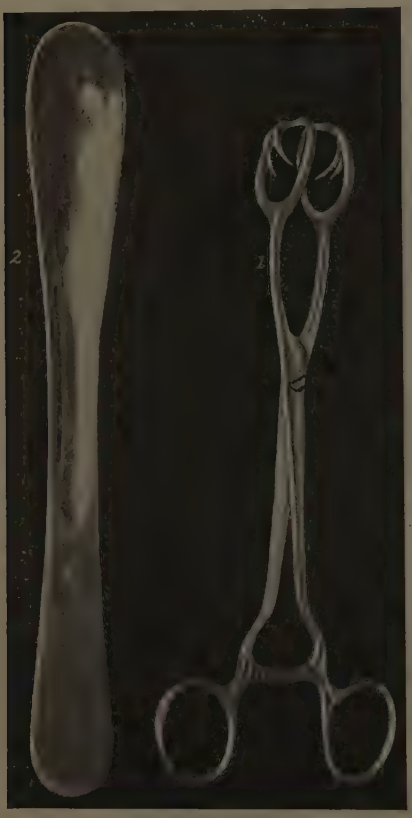


FIG. 237.—KOCHER'S INSTRUMENTS FOR GOITER OPERATION.
1, Forceps for seizing goiter; 2, elevator for lifting up intrathoracic goiters.

In *resection* the arteries are not ligated. The part to be resected is exposed as freely as possible and, after the application of hemostatic forceps (angiotriptors), a ligature is applied to the remaining portion of the gland. Resection of a wedge-shaped piece, followed by the introduction of sutures, is not advisable because the tissue that remains is damaged and the symptoms are only partially relieved.

Combined methods include the following: Primary division of the isthmus, avoiding both arteries. Resection or enucleation, leaving the posterior rim of the goiter; or ligation of the inferior thyroid artery and resection and enucleation, leaving the upper horn preferably after application of large hemostatic forceps (histotriptors), and ligation *en masse*. All of the inferior horn should not be allowed to remain on account of the danger of recurrence and its attendant symptoms.

In *enucleation* the nodule or nodules should be delivered out of the wound as far as possible. The capsula propria is incised at the level of the nodule, stripped back with blunt dissector, picking

up the bleeding vessels and pulling on the nodules at the same time. Sometimes exenteration of the nodule may be necessary. The capsular vessels are ligated *en masse* after applying large hemostatic forceps.

In *exenteration* the capsula propria is incised as soon as it comes into view and the contents turned out (exenterated) with the hand or a sharp curet. The wound is packed or a secondary excision is performed; or, in the case of small nodules, the capsule is compressed at the base and ligated.

Ligation of the Inferior Thyroid Artery.—The goiter is delivered and drawn well over toward the median line, and the trunk of the artery exposed and ligated between the carotid artery and the recurrent laryngeal nerve. The goiter is then replaced.

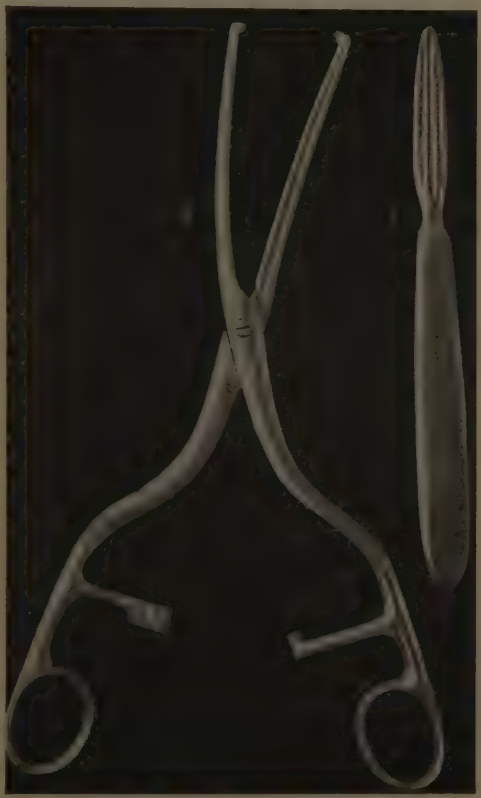


Fig. 238.—Kocher's Instruments for Goiter Operation.
1, Goiter probe; 2, angiotribe.

The *superior thyroid artery* is ligated through a short incision in the direction of the cleavage lines of the skin, dividing skin and platysma and separating the omohyoid and sternocleidomastoid with a blunt dissector. If necessary, the carotid may first be exposed.

After removal of the goiter or part of the goiter, according to one of the described methods, the operation is terminated as follows: the vessels are ligated, the divided muscles are carefully sutured, and the median intermuscular fascia between the two sternohyoids as well as that between the omohyoid and sternocleidomastoid muscles is united. A drainage-tube is inserted to the bottom of the wound and the wound closed with a continuous suture of the skin.

Sequels and Complications of Goiter Operations.—Grave complications are to be feared only when the above-mentioned contra-indications have been disregarded, when the operation has been performed carelessly, in the presence of cachexia thyreopriva, and when the resisting power of the organism is diminished. Cases of this last kind require preliminary treatment. *Postoperative pneumonia* is not more common than after other operations, provided general anesthesia is avoided as

much as possible. *Embolism* is very rare. *Tetania parathyreopriva* can be avoided by preserving the parathyroid glands. Details in regard to this question will appear in another publication. *Secondary hemorrhage* is rare if general anesthesia and, therefore, vomiting are avoided and the patient is kept quiet after the operation. Injury to neighboring organs can be avoided in ordinary goiters. Often it is difficult to avoid injury of the recurrent laryngeal nerve. Unilateral temporary injury of this nerve by contusion or distortion is followed by hoarseness, which usually is of short duration. If the injury is permanent, the hoarseness persists a long time. Even when there is complete unilateral paralysis, the patient can be trained to effect closure of the glottis by causing the sound vocal cord to swing over toward the paralyzed cord; singing, however, is impossible.

Recurrence of Goiter.—So long as the cause of the goiter-formation persists, the tumor may recur. Recurrence depends on whether the operation has removed the factors which influence the growth of the tumor. Portions of the gland that were healthy before the performance of strumectomy do not recur, that is to say, they do not become goitrous, evidently because they are not predisposed to the disease. Diffuse hypertrophic goiters recur much more rarely than nodular goiters, evidently because after excision of one portion of the tumor the circulation is improved in the remaining portions. Recurrence produces symptoms chiefly when it is bilateral; hence the symptoms are much milder after excision. Operation on a recurrent goiter is much more difficult than the primary operation, partly because of the necessity of preserving some of the gland tissue and partly on account of the presence of scars and cicatricial adhesions.

INFLAMMATION (THYROIDITIS—STRUMITIS).

We must distinguish between inflammation of the normal thyroid gland (thyroiditis) and inflammation of a goiter (strumitis). The former, particularly the purulent form, is *much* more rare than the latter, because the degenerative processes present in goiter predispose to inflammation (Kocher) and particularly to circulatory disturbances and their results, hemorrhages and necrotic changes. It should be especially emphasized, however, that colloid goiters, and especially those which contain large quantities of thick colloidal material, do not tend to become inflamed; on the contrary, they resist inflammation, which may be in part due to the large quantity of iodin which these colloid goiters contain. Thyroiditis, therefore, occurs preferably in hypertrophic parenchymatous glands.

Acute thyroiditis may be purulent or nonpurulent and, in contradistinction to acute strumitis, is much more frequently nonpurulent than purulent. It is caused by bacteria or by toxins, usually by metastasis, in typhoid fever, diphtheria, scarlet fever, measles, erysipelas, influenza, cholera, malaria, articular rheumatism, parotitis, angina, pneumonia, and enteritis. Toxic thyroiditis caused by chemical poisons is not an inflammation in the true sense of the term. It has

practically no clinical significance as such, except possibly when it leads to a functional alteration of the gland (*q. v.*).

Pathology.—The inflammation produces in the thyroid gland a leukocytic infiltration, increase and desquamation as well as degeneration of the epithelium and thereby an alteration and ultimate disappearance of the colloid material, and, if the inflammation continues, connective-tissue organization. These changes are attended by distinct, and often considerable swelling of the gland. In the purely toxic form emigration of leukocytes is said to be wanting (de Quervain).

The **diagnosis,** aside from the history, which is very important, is based on increased consistency and sensitiveness to pressure, as well as increase of volume of the thyroid gland.

The **symptoms** vary in severity according to the degree of inflammation. They are: 1. Spontaneous local inflammatory pain; 2, pain radiating into the second, third, and fourth cervical nerves—ear, neck, teeth, upper and lower jaw, shoulders, arms, and chest; 3, pain on swallowing.

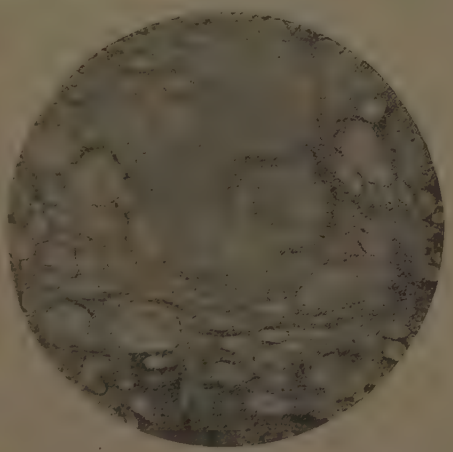


FIG. 239.—ACUTE THYROIDITIS. (After de Quervain.)

A more characteristic symptom, which is not so frequent as pain, is interference with respiration; it occurs particularly when the inflammatory swelling is bilateral and develops suddenly.

In addition we have the general symptoms of inflammation—fever, chills, nausea, headache—which, however, are present practically only in the bacterial purulent form. Examination of the blood is important. The thyroid gland itself is less movable than under normal conditions. Adhesions to surrounding structures and absolute immobility of the gland occur only with purulent inflammation and, in addition, are accompanied by infiltration, redness, and elevation of temperature. Temporary hoarseness may occur; it is not always the result of paralysis of the recurrent, being frequently produced by accompanying laryngitis, which is always responsible for the existing cough. Partial paralysis of the sympathetic is rare, much more rare than in strumitis.

Course and Prognosis.—The course is usually rapid. The symptoms attain their maximum in a few days and then subside again quite rapidly. As a rule the entire gland is involved; in most cases the normal volume of the gland is restored; but the enlargement may persist and a chronic thyroiditis may develop. This, however, is usually the result of some chronic cause. In purulent thyroiditis the duration is longer; the primary acute stage is followed by a protracted secondary

stage. There are usually small multiple abscesses, rarely one large pus cavity. Rupture of the abscess into the surrounding tissues or externally is rare. The *prognosis* is almost always good, unless it is clouded by the accompanying infectious disease. In cases with suppuration the prognosis is somewhat more unfavorable. The most important effect of the suppuration is impairment of the thyroid function. Suppuration and necrosis may bring about destruction of a large portion of the gland tissue, with resulting hypothyroidism; or the function may be impaired by the development of marked fibrous induration. It is equally certain that the inflammation may be accompanied or followed by symptoms of hyperthyroidism or thyro-intoxication. The *post hoc ergo propter hoc* argument, however, cannot be accepted without reserve.

The **treatment** of acute thyroiditis is like that of other inflammations. Special remedies are indicated, depending on the nature of the antecedent infection, such as the salicylates in rheumatism; quinin in malaria. The presence of pus is difficult to demonstrate and premature incision must be avoided. If necessary, the gland itself should be exposed. If incision of the abscess is not followed by rapid recovery, the presence of multiple abscesses should be suspected. Fistula points to extensive necrosis. In such a case the affected half of the gland must .be excised. Partial thyroidectomy may also be considered in cases of thyroiditis that have become chronic and in chemicotoxic thyroiditis.

STRUMITIS.

Inflammation of a goiter is rare and is destined to become still more rare because, as the small danger of operations become generally known, goiters will be extirpated more frequently and at an earlier stage, particularly as those forms which show a special tendency to inflammation—large cysts and parenchymatous nodules—are peculiarly amenable to operative treatment.

Etiology.—Inflammation of a goiter is almost always of bacterial origin, due to the deposition of infectious substances circulating in the blood or to similar infections from without, as a result of traumatism, including puncture and injections. As in the case of thyroiditis, the infection is derived chiefly from the infectious diseases—strumitis following typhoid fever, pneumonia, puerperal fever, osteomyelitis, cholera, dysentery, and polyarthritis. In the main, however, these grave infectious diseases are of less importance in this respect than milder infections, such as angina, laryngitis, bronchitis, enteritis, and staphylomycosis of the skin. Predisposition is always an important factor and is always present in goiter on account of the circulatory disturbances and their consequences, while this is not the case in the normal gland. It must be borne in mind too, that the circulation in a goiter may be influenced by a variety of causes and is subject to sudden changes, so that the disposition to inflammation may be increased at the time of infection. We need only refer to the marked venous stasis in a goiter which accompanies cough, sudden exertion of various kinds, etc. Bac-

terial strumitis is particularly apt to develop in cysts and greatly degenerated nodules; it is rare in the diffuse forms and occurs then chiefly in parenchymatous struma.

Non-bacterial, toxic strumitis occurs in diffuse goiters only or in diffusely hypertrophied parts of a nodular goiter, particularly in the parenchymatous form. Like toxic thyroiditis, it bears some relation to functional anomalies of the gland (*q. v.*).

Symptoms.—Most important are local inflammatory pain in the goiter and increase or occurrence of dyspnea with augmentation in the volume of the goiter. The tumor becomes sensitive to pressure, and its mobility is impaired as soon as the inflammation extends to the surrounding structures (peristrumitis). The gland ceases to move during swallowing. Dysphagia is much more frequent than in ordinary goiter and is painful. If the neighboring nerves are involved, radiating pains as in thyroiditis, hoarseness and paralysis of the sympathetic may occur. The latter is relatively frequent in strumitis and less common in malignant goiter, although it may also occur in that condition. A characteristic feature is found in the frequent involvement of the laryngeal and tracheal mucous membranes which become swollen and edematous as a result of the inflammation and may produce hoarseness, cough, dyspnea, and attacks of asphyxia.

In addition we have the general symptoms of inflammation, which must be carefully studied, particularly in the differential diagnosis from malignant goiter. The most important is fever, which is never absent at the beginning, later is irregular, and may be of the hectic or remittent type. Chills are quite characteristic. General malaise, headache, and prostration may be present. These symptoms must be distinguished from the cachectic symptoms of malignant goiter.

If an abscess forms and is confined to the goiter, the consistency of the goiter becomes tense and elastic, and it may be possible to demonstrate fluctuation. Rupture of the abscess into the surrounding tissues may be followed by a deep cervical phlegmon and its attendant dangers. More frequently it ruptures externally. Puncture of the abscess is permissible for diagnostic purposes, but the surgeon should be prepared to follow it with immediate incision. Cultures should always be made. The occurrence of softening and suppuration in malignant goiter and its significance for the differential diagnosis must be borne in mind. Examination of the blood should never be neglected.

Course and Prognosis.—The course of strumitis may be rapid or slow, depending on the character and the virulence of the infection. If suppuration does not take place, the inflammation and its symptoms rapidly subside. If a circumscribed abscess develops, the duration may be protracted and spontaneous recovery may take place by absorption. If the suppuration continues to spread, it may become dangerous like any other form of inflammation. The chief dangers are dyspnea with a very possible asphyxia from pressure, and extension of the inflammation and perforation into the trachea, esophagus, pleura, mediastinum, and large vessels. Rupture toward the exterior or underneath

the skin is, however, the most frequent termination. Fistulæ are particularly apt to result in cases of calcified and inflamed cysts.

Treatment of Strumitis.—The *non-purulent* form usually subsides spontaneously under the same remedies as are employed in other forms of inflammation. Occasionally injections of carbolic acid, iodoform, and iodin have to be employed.

If *suppuration* takes place, it must be determined as early as possible whether the condition is a simple strumitis or complicated by peristrumitis, and what the nature of the infection is. If the suppuration is confined to the goiter, and the surrounding tissues are not involved, and if the general symptoms are not severe, *excision* of the goiter is the best procedure. The indication for this operation is even clearer when it has previously been determined by puncture that the bacteria have already disappeared from the pus or, if any are found, that they are non-virulent—particularly colon bacillus or staphylococcus albus. The operation may be preceded by aspiration of the pus and injection of some antiseptic substance.

If *peristrumitis* is present, formal excision is usually not feasible, particularly if the abscess has ruptured. In such a case the pus must be evacuated as soon as possible by incision or puncture. If the abscess is superficial it may be opened with the thermocautery in order to avoid injuring the vessels.

CHRONIC THYROIDITIS AND STRUMITIS.

These are caused by tuberculosis, syphilis, actinomycosis, and echinococcus. There are, in addition, other chronic forms of inflammation which are not due to the above causes or cannot be positively demonstrated by pathologic examination.

CHRONIC THYROIDITIS.

This is not so frequent as chronic strumitis. In most cases the etiology cannot be accurately determined. The disease usually develops in an already hypertrophied gland. The latter is enlarged, the consistency is increased, there is sensitiveness on pressure, and the gland is somewhat adherent to the surrounding tissues and accordingly a little less movable than normal. The skin and muscles are not affected. In contradistinction to what occurs in malignant disease and acute thyroiditis, the surrounding parts are free.

Pathology.—There is a distinct and quite extensive round-cell infiltration in the lobules and in the interlobular stroma, exhibiting a more focal arrangement. In the areas of round-cell infiltration there is desquamation of the epithelium and the colloid disappears, but these changes are much less marked than in acute inflammation. In protracted cases proliferation of connective tissue takes place, the process beginning in the stroma of the foci of round-cell infiltration, and atrophy of the neighboring follicles results. In the unaffected portions the follicles are distended with dark colloid material. The pathologic pic-

ture in that case strongly resembles that of the experimentally produced changes in the thyroid gland by the administration of iodin or injection of iodin into the goiter. Chronic thyroiditis usually occurs after the fortieth year of life in individuals affected with arteriosclerosis, in alcoholism, early syphilis, chronic tuberculosis, and, whenever iodin has been given for a considerable length of time, especially locally in the thyroid. The general condition must, therefore, be carefully investigated in every case, and examination of the blood must not be neglected.

Course and Prognosis.—As a rule the patients do not present themselves for treatment at all, at least to the surgeon. The intensity of the inflammation is variable, hence the symptoms, which are never pronounced, often remain permanently latent. The course is protracted. If the process is progressive, functional disturbances may develop from secondary atrophy; but as the process is never extensive, the functional disturbances are rarely severe. Mild cases, owing to the advanced age of the patients, usually escape detection. Suppuration does not take place.

Treatment.—This consists in removing the cause. Iodin treatment must be stopped and our method of treatment with phosphorous substituted. If there are symptoms of functional impairment, thyroid gland preparations must be given. *Operation* is always indicated when one part of the gland is altered and whenever dyspnea is present. If possible, the larger half, which exerts most pressure, should be removed. It is not advisable to resect more than half of the gland on account of the danger of thyroid insufficiency.

CHRONIC STRUMITIS.

This is not a rare disease. It occurs in adults only, chiefly elderly individuals, and develops in goiters of long standing which are considerably degenerated, particularly in old hemorrhagic cysts. The *cause* cannot be determined with certainty. It is certainly not *always* bacterial, usually no microörganisms are found after puncture or at operation. Chronic strumitis most frequently follows hemorrhage into the goiter.

Symptoms.—After some relatively mild or chronic infectious disease a previously existing goiter suddenly begins to grow at a more rapid rate, the consistence changes, and the tumor becomes more tense and firm, and somewhat sensitive on pressure. The symptoms, which previously had been mild, increase in severity. The mobility of the goiter becomes slightly impaired. On careful examination it is found that the muscles cannot be lifted away from the tumor as well as before, or not at all. In contradistinction to acute strumitis and malignant goiter, spontaneous or radiating pain does not occur, and there are no symptoms of paralysis of the recurrent laryngeal or of the sympathetic. Examination of the blood must not be neglected. The general condition has to be watched, especially occasional rise of temperature.

Pathology.—As a rule, a single, large, degenerated, inflammatory nodule is found; occasionally there may be several nodules. The

capsule of the centrally softened nodule is greatly thickened and consists for the most part of sclerotic connective tissue, rarely of compressed gland lobules. The capsule, and particularly the vessels, are surrounded by foci of mononuclear leukocytes and frequently by fatty tissue and calcareous deposits. The capsule may be adherent to the muscles above and is then the seat of lardaceous infiltration and here and there contains granulation tissue. The contents of the nodule are composed of a semifluid, yellow or yellowish-brown material varying in consistency and made up chiefly of necrotic tissue, numerous fat droplets, and calcareous débris. If the contents are fluid they contain degenerated red and white blood-cells, small spherical collections of granules, and cholesterin crystals.

The *diagnosis* is difficult. An accurate history is absolutely indispensable. The condition must be differentiated from malignant, and particularly hemorrhagic goiter. The great majority of the cases of chronic strumitis are associated with hemorrhagic goiter. If there is hemorrhage, the tumor tends to break down and become infected.

Prognosis and Course.—In elderly persons, in whom chronic strumitis is most frequent, the prognosis is not always favorable. Spontaneous recovery practically never occurs. Acute inflammation is very apt to develop. Owing to their marked tendency to necrosis, these goiters do not become malignant. On the other hand, the possibility of previous malignant degeneration and *secondary* softening must be thought of *in every case* of chronic strumitis.

Treatment.—*Extirpation* of the chronically inflamed goiter is the best treatment. Operation is much more difficult than in ordinary goiter on account of the adhesions and the lardaceous infiltration and induration of the surrounding tissues. In most cases enucleation, or enucleation combined with resection, is the only possible procedure. If the patient's condition forbids an extensive operation, the goiter may be opened and the contents evacuated (exenteration). When the capsule is unusually thick, and particularly when it contains necrotic or calcareous foci, the wound may fail to heal and fistulæ may develop. Injections of iodin, iodoform, carbolic acid, and phenol-alcohol are not always followed by absorption and diminution in the size of the goiter, and when successful the effect in most cases is only temporary. The injection is painful and not altogether without danger on account of the possibility of hemorrhage. Percutaneous and internal medication usually fail altogether.

SYPHILIS OF THE THYROID GLAND.

Syphilis occurs in the thyroid gland, as in all other vascular tissues and organs. It is, however, a rare, and indeed, in view of the vascularity of the gland, an exceedingly rare disease, although it must be acknowledged that, owing to the relative innocuousness of the malady, few cases have been reported and, especially, few histologic investigations are available. We cannot help believing that the iodin contained in the gland is responsible for its comparative freedom from the disease.

Syphilis of the thyroid gland yields very rapidly to iodin treatment. It is of great interest also to note that during antisyphilitic treatment an induration as well as an enlargement of the thyroid gland sometimes occurs, and disappears again after antisyphilitic treatment has been withdrawn. Cases have recently been described in which the enlargement of the thyroid gland which developed during a course of antisyphilitic treatment persisted for years, and then gradually subsided and assumed the character of chronic thyroiditis, which remained entirely uninfluenced by specific treatment. Great caution is necessary in making the diagnosis of syphilitic thyroiditis.

(1) *Syphilis of the thyroid gland in recent lues* has never been described histologically. Clinically, enlargement of the gland has been observed in about one-half of the cases of florid syphilis in which the symptom was looked for, although the condition is only exceptionally accompanied by mild pressure symptoms. It is important to determine whether the enlargement occurred with, and possibly on account of, the treatment.

(2) *Late syphilis of the thyroid gland* occurs both in the congenital and in the acquired form. (*a*) Congenital syphilis of the thyroid gland manifests itself in the appearance of small gummatous nodules in an otherwise normal gland. The nodules are grayish red or grayish yellow, and show the characteristic histologic structure of gumma. They do not produce any clinical symptoms. As regards treatment, their behavior does not differ from that of gumma in other organs.

The form of chronic thyroiditis which is seen in the thyroid glands of children suffering from congenital syphilis does not differ from chronic thyroiditis in general, and is therefore not to be regarded as a specific form—as specific thyroiditis.

(*b*) In adults *syphilis of the thyroid gland* occurs as an independent disease, or in association with other specific manifestations, in the secondary and tertiary stages of the disease. So far 5 indubitable cases have been described, 2 by Kuttner and 3 by Mendel.

Pathology.—The well authenticated cases that have been described were cases of specific changes occurring in goiters. The goiter first exhibits fibrous degeneration with destruction of the specific gland elements. This is followed by the appearance of granulation tissue in the form of circumscribed foci and round cells, with characteristic giant-cells at the periphery of the focus. This tissue may degenerate to an amorphous mass containing granules and nuclei. The tendency to caseation is, however, not marked.

The goiter is thus converted into a large, irregular tubercular tumor of the consistency of a hard-rubber ball. The cut surface is white or whitish-yellow in color, lardaceous and opaque, and does not exude any tumor juice. The pathologic diagnosis is positive only when the round-cell infiltration and typical fibrous degeneration can be demonstrated, chiefly in the intima and also in the adventitia.

In the absence of these characteristic changes in the vessels the diagnosis may be confirmed by the absence of tubercle bacilli and the

negative results of animal inoculation. The spirocheta pallida of Schaudinn has never been demonstrated.

Symptomatology and Diagnosis.—All the cases in which the diagnosis has been confirmed by histologic examination were diagnosed as cases of malignant goiter. We know of no positive clinical signs. The patient's age may be utilized in excluding carcinoma; moreover, specific goiters are characterized by fairly rapid, painless growth. The surface is less tubercular, the consistency uniform, not hard but rather firm and elastic. The tumor does not become adherent to the surrounding tissues, and the symptoms depending on that condition are therefore absent. Pressure symptoms, on the other hand, are quite prominent on account of the rapid growth of the tumor. Signs of syphilis in other parts of the body and the results of specific treatment form the main support of the diagnosis.

Treatment.—If there is any good reason to suspect the syphilitic nature of the tumor, the diagnosis is at once confirmed by the effect of suitable treatment with potassium iodid and mercurial ointment, as this may be expected to produce prompt and complete cure. It is for this reason that cases of this kind probably do not often come under the physician's notice, because the condition yields at once to the iodin treatment which is so universally employed for the cure of goiter.

The treatment need not be kept up for any length of time. Unless the effect is immediate and convincing, the diagnosis is at fault. We must especially guard against the error of mistaking a malignant goiter for a specific tumor, and of persisting in antisyphilitic treatment when the administration of iodin is followed by some improvement, since the drug obviously acts upon that portion of the goiter which has not yet become carcinomatous.

TUBERCULOSIS OF THE THYROID GLAND.

Atrophy and connective-tissue degeneration of the thyroid gland, which are relatively frequent in *chronic pulmonary tuberculosis*, are in no sense specific, and cannot be recognized clinically except in very rare cases.

In *miliary tuberculosis* a crop of tubercles is very frequently found in the thyroid gland; owing to the severity of the other manifestations, however, this form of tuberculosis is not conspicuous clinically.

At autopsies on *tuberculous patients nodules exhibiting typical structures of tubercle*, and often with caseation, are not infrequently found in the thyroid gland (4 to 12 per cent.) besides. Signs of chronic thyroiditis, such as are seen in chronic tuberculosis without special involvement of the thyroid gland, may also be present. These alterations of the gland, which have been found at autopsies, have not been recognized clinically, and it is difficult to make any definite statement in regard to their frequency, nevertheless, the same form of tuberculosis is known as a clinical condition, although it is extremely rare. Whether it is a primary tuberculosis cannot be decided. In the cases that have been reported the tuberculosis first made its appearance clinically in the

gland. It is worth noting that all of the reported cases occurred in individuals beyond the age of thirty or forty.

Clinical Symptoms and Diagnosis.—A hard swelling of the thyroid gland, which is sensitive on pressure, develops in the course of a few months or years in an individual whose neck had previously been regarded as normal. The enlargement is not very great and usually betrays itself by the pain which it produces. The pain radiates into

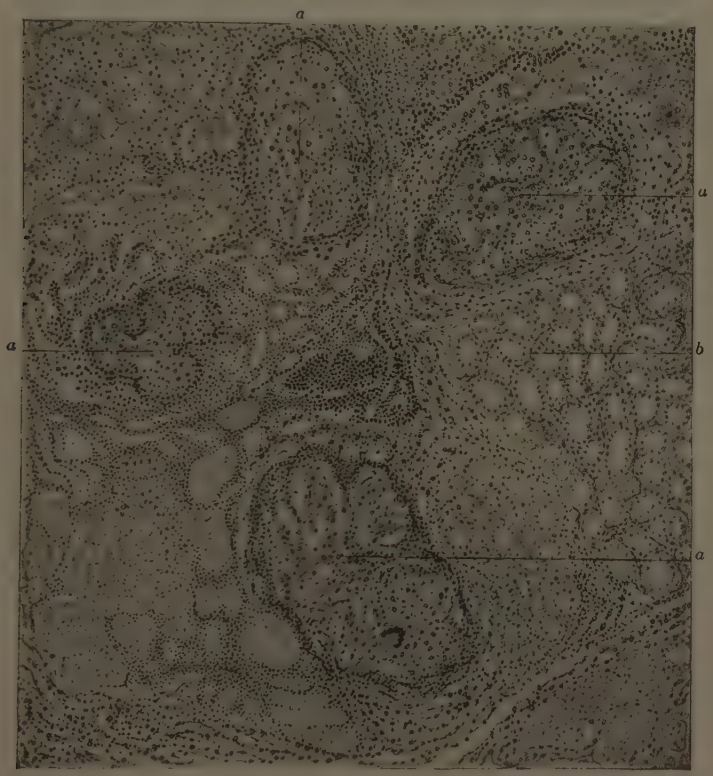


FIG. 240.—MICROSCOPIC DRAWING OF TUBERCULOSIS OF THE THYROID GLAND, 4 oc. 3 obj. Leitz.
(a) Tubercles, in the lower one of which is seen a giant-cell. In the center of the drawing, between the tubercles, is an area of lymphocytic infiltration. (b) Normal thyroid tissue (after George Everett Beilby).

the auricular and the occipital nerves; paralysis of the recurrent laryngeal and of the sympathetic has been observed. The surface of the swelling is moderately rough, and the tumor is sensitive on pressure and less movable than an ordinary goiter; hence it gives the impression of being adherent to the surrounding tissues. Pressure symptoms are not marked.

If caseous degeneration takes place, individual portions of the gland are felt to be softer than others. The gland in such cases is less sensitive to pressure. Perforation may take place with the production of fistulæ, which obstinately resist treatment.

Enlarged or tuberculous lymph-glands cannot be demonstrated. What has been said so far applies to tuberculosis of the normal thyroid gland.

Tuberculosis in a goiter is much more rare. Among 3200 thyroid glands excised by Kocher there was only one instance. Owing to the rarity of the disease the clinical diagnosis is not clear.

MALIGNANT DISEASES OF THE THYROID GLAND.

These belong to the frequent diseases of the gland and, owing to the position of the organ, the prognosis is more unfavorable than in the case of malignant disease elsewhere.

It is comparatively rare for malignant tumors to develop in a normal thyroid gland, while diffusely hypertrophic glands are frequently attacked, and still more frequently nodular goiters.

MALIGNANT GOITER.

This is a generic term for all malignant degenerations occurring in the healthy or diseased thyroid gland. The pathology of the process is extremely various. The thyroid gland is the field *par excellence* for the study of the histogenesis of tumors, partly on account of the frequency and variety of the benign forms of tumor and partly on account of the great vitality of the specific gland elements.

Pathology.—We distinguish: (1) *Connective-tissue* tumors; and (2) *epithelial* tumors, but accurate histologic examination is often required to make the differential diagnosis. Both forms of tumor have been demonstrated in the same gland.

I. **Sarcoma.**—Sarcoma develops preferably in goiter nodules, especially in such as already exhibit secondary degeneration and in which, therefore, the stroma is already in process of abnormal metaplastic change. The *spindle-cell variety* is the most frequent; next, sarcomata composed of polymorphous cells, frequently combined with giant-cells which may contain one or more nuclei of large or small size. *Round-cell* sarcoma is less frequent. The round cells are usually large, rarely small. This variety sometimes resembles lymphosarcoma, and occasionally may be difficult to distinguish from lymphoma. *The type of sarcoma of the thyroid gland* is a tumor in which the cells predominate and which contains but little connective tissue and few cleft-like blood-vessels. The gland follicles are almost completely destroyed. The tumor is quite sharply differentiated from the surrounding tissue or it may be confined to a portion of the gland or a single nodule; the process is rarely diffuse. The tumor is soft like the brain; it is friable and does not exude any juice; the cut surface is grayish white. In rare cases the tumor contains numerous vessels which resemble irregular clefts in the tissue. The tumor-cells grow into the vessel-walls, which they gradually obliterate, as can be directly demonstrated by the presence of stratified elastic fibers which can be recognized even in the late stages. This is quite characteristic of

sarcoma. This form of sarcoma tends to undergo softening from necrosis, fatty degeneration, and calcification.

(1) The next most frequent form is *fibrosarcoma*. It is characterized by irregular proliferation of the connective tissue and of the intracellular substance. This variety also is usually a spindle—rarely a round-cell—sarcoma. These tumors are not infrequently the seat of inflammation. The consistency is more firm, depending on the development of the connective tissue; the cut surface is whitish and, if there is much connective tissue, of a glistening white color; the tissue is resistant and no juice can be expressed.

(2) *Osteosarcoma* of the thyroid gland also tends to develop chiefly in nodules. The tumors are spindle-celled sarcomata that have been converted into true bone. Genuine bony trabeculæ with bone corpuscles are found, and the meshes contain the sarcoma cells. The consistency of these tumors is that of bone.

(3) *Angiosarcoma.*—This is very rare. It appears in the form of

(*a*) *Endothelioma*, produced by proliferation of the endothelial cells of the intralobular capillaries, with gradual obliteration of the lumina of the blood-vessels and the formation of cell cords and alveolar cell nests. There is marked proliferation of connective tissue.

(*b*) *Alveolar angiosarcoma*, from proliferation of the endothelial cells of the interlobular capillaries and veins, with the formation of large cells resembling epithelial cells; and preservation of the lumina of the blood-vessels which assume the form of ramifying clefts; hence the tumor is also called cavernous angiosarcoma.

These tumors do not attain a large size. They are exceedingly hard and somewhat nodular.

II. **Epithelial Neoplasms.**—These occur in much greater variety than has hitherto been supposed. We distinguish:[1]

(1) *Genuine carcinoma of the thyroid gland*, the true epithelial form, the most frequent neoplasm of the thyroid gland, which is produced by alteration and proliferation of the epithelial cells of the follicles. The cells are later destroyed and replaced by cancer nests, which proliferate in an irregular manner. Secondary proliferation of the connective tissue takes place. The cells exhibit a variety of forms; they are usually very large, with large, vesicular nuclei; giant-cells with multiple nuclei also occur. The cells may undergo mucoid, fatty, or hyaline degeneration. If the cells only proliferate, the tumor is called a medullary cancer; when both the cellular and the connective tissue are increased, we speak of a simple cancer; while the term scirrhous cancer is employed to designate a tumor in which the secondary proliferation of connective tissue predominates. This distinction, however, has but little value.

Cancer of the thyroid gland presents as a hard tubercular tumor with a grayish-white cut surface, usually of lobulated structure, in which the tissue appears opaque and dry; typical cancer juice can be

[1] The classification corresponds to that contained in the most recent researches of Langhans and Kocher, which have not yet been published. The diagnosis of the individual forms of malignant goiter will, however, also be discussed.

expressed. Carcinoma tends to undergo softening, especially when it develops in a goitrous nodule in a state of partial secondary degeneration. Softening not infrequently follows hemorrhage into the nodule.

(2) *Proliferating Goiter* (Langhans); *Malignant Adenoma* (Kocher).—It occurs in the form of nodules or as a diffuse process involving numerous lobules. The tumor consists of solid masses of cells and cell-cords arranged at the periphery of the lobule, and uniting toward the center in various ways to form tubes and follicles. Some of the follicles are empty, others rarely contain colloid material. The cells in almost every part of the tumor resemble those of the normal thyroid, being cuboidal or low or high columnar cells. The nuclei are vesicular or homogeneous. The connective-tissue septa are usually narrow; in other cases they are somewhat broader.

Along with these tumor elements, the gland in every case without exception contains portions which have the same structure as that of the normal thyroid or of an ordinary goiter. As a rule but little colloid material is present.

Proliferating goiter has a firm, although more fleshy, compact consistency, and its size is usually inconsiderable. The cut surface, in parts at least, is like marrow, grayish white, contrasting with the reddish color of the surrounding tissue. The consistence in such places is harder; no juice can be expressed. Proliferating goiter is the second most frequent neoplasm of the thyroid gland.

(3) *Metastatic Colloid Goiter.*—There are tumors of the thyroid gland the pathologic appearance of which, according to the latest, most accurate investigation by Langhans, is in no wise different from the well-known picture of nodular goiter, either in the primary or in the metastatic tumor. Follicles are found with cuboidal, squamous, and cylindric epithelium; the colloid material in the first variety of follicles is of about the average quantity and tingibility; in the second it is increased and stains more darkly; in the third it is diminished or absent and stains but faintly. In other words, we find the same conditions as in the normal gland, or struma benigna. These tumors are exceedingly rare.

(4) *Papilloma* of the thyroid gland may be nodular or diffuse. It consists in an irregular growth of the follicles, which contain high cylindric epithelium and ramify in various ways. The epithelium encroaches on the lumen in the form of papillæ, and the papillæ again break up into ramifications. Every conceivable transitional form between normal follicles and branching follicles is seen. The colloidal material diminishes; the normal portions are usually found at the periphery; the connective tissue is not abundant and forms the central core of the papillæ. The tumor is not very large; in the nodular form the nodules are usually small, fairly smooth of surface, and of firm, fleshy consistency.

(5) *Cancroid Squamous Epithelial Cancer of the Thyroid Gland.*—This is a rare tumor. Its starting point is not definitely known. It is noteworthy that in almost every case tumors of this kind extend to the

pharynx and larynx, and it is, therefore, possible that the tumor may have its beginning in the epithelium of the pharynx or of the larynx, or in rests of the ductus thyreoglossus (Langhans). It is certainly remarkable that rupture always takes place at the same spot—near the first tracheal ring and behind the trachea. The theory that they originated from aberrant embryonal rests has not been proved. The tumor consists of broad, solid cell cords, composed of very large, polyhedral cells with large ovoid, vesicular nuclei. In places there is distinct striation and epithelial pearls (cancer pearls) are formed in considerable numbers. The stroma is poorly developed. The tumor has an irregular surface and develops with equal frequency in normal and in hypertrophic glands and in a goiter. It is very hard. The cut surface has a white, marrow-like color and is of firm consistence. Juice can be expressed. The cell-nests (cancer nests) can often be expressed like comedones. In accordance with the frequency with which perforation takes place in the pharynx and larynx, the tumor frequently becomes inflamed and undergoes softening; rupture toward the exterior may even take place. Early involvement of the nerves, especially the sympathetic and recurrent laryngeal, is a noteworthy feature.

(6) *Glycogen containing epithelial goiter* (Th. Kocher, Jr.) develops in nodular goiter and is characterized by rapid growth and the occurrence of symptoms of pressure, adhesions, and increase in consistency, which becomes practically solid. The goiter shows a typical alveolar structure; the alveoli vary in shape and size and are completely filled with cells; the cells are large, polygonal, sharply outlined, with a colorless cell-body containing a variable quantity of glycogen and large round vesicular nucleus, rich in chromatin. The alveoli are embedded in a delicate reticulum of connective-tissue fibers containing a few small capillaries; in places the stroma is absent; irregular proliferation of the cells does not occur. The goiter is nodular; the nodules themselves are smooth, the consistence is firm. The cut surface is distinctly gray, dirty gray, or grayish brown; the transparency is diminished and juice can often be expressed. This tumor has its starting-point in parathyroid tissue.

(7) *Small alveolar epithelial goiters* may be compared to the glycogen-containing variety, from which they differ only by the fact that the cells do not contain glycogen. The structure is typically alveolar; the alveoli are regularly rounded, but small; the cells are very large, cylindric, and resemble liver-cells. This tumor has its starting-point in the epibranchial body (Getzow).

Combinations of the Various Forms of Malignant Goiter.—Carcinoma and sarcoma may occur at the same time in the thyroid gland, but the combination is very rare. I do not refer to cases of endothelioma, for instance, which are regarded by some as sarcoma, while others describe them as carcinoma; I mean the occurrence of separate, but undoubtedly epithelial and sarcomatous portions in the same goiter. These combinations are exceedingly rare. They have been observed as cancroid goiter with spindle-cell sarcoma; alveolar

carcinoma with spindle-cell sarcoma; and glycogen-containing epithelial goiter with spindle-cell sarcoma.

It is certainly remarkable that the combination has apparently been observed beyond the possibility of a doubt only in cases in which there was some doubt that the epithelial tumor in the primary gland was primary.

Various forms of sarcoma may occur in the same tumor. The epithelial forms, according to Langhans' classification, rarely occur in combination; for example, a proliferating goiter may occur in combination with a papilloma, or an alveolar, or a glycogen-containing goiter. Positive proof is difficult. *A certain histologic diagnosis of malignant goiter* in many cases can be made only when the tumor cells have invaded the blood-vessels or surrounding tissue—too late, therefore, to expect a radical cure.

The characteristic features of malignant goiter are: (1) The tendency to metastasis; (2) extension to surrounding structures.

Every malignant goiter produces secondary metastatic growths by way of the lymph- or blood-channels, particularly the latter, because the vascularity of the thyroid gland, whether normal or diseased, favors invasion of the blood-vessels, especially the veins. Secondary tumors resulting from metastasis by way of the blood-channels differ from malignant tumors of other organs in that they are found with special frequency in bones. Epithelial malignant goiters somewhat more frequently produce metastatic growths in bone than do sarcomata. In carcinoma the metastatic tumor is most frequent in the skull, and next in the ribs and jaws. In sarcoma, the sternum and ribs and, next to these, the long bones and the scapula are the most frequent seats of metastasis. The metastatic tumors that develop in bones are more frequently solitary than multiple. The most common seat of metastasis in malignant goiter is not in the bones, however, but in the lungs, although the metastatic bone-tumors develop earlier than the pulmonary growths. Next in order of frequency to the lungs are the bones, the liver, the kidneys, and the pleuræ; in the remaining tissues metastases are rare.

Metastasis in lymph-glands is somewhat more rare in sarcoma than in carcinoma. As a rule the metastasis does not take place until after the primary tumor has broken through the capsule of the thyroid gland. The metastases develop in the deep jugular glands; inferior superior deep cervical glands; then in the mediastinal, bronchial, cardiac, supra-, sub-, and infraclavicular, axillary, submandibular, and sublingual glands. The structure of the metastatic tumor is the same as that of the primary growth in all the varieties of malignant goiter that have been named.

Clinical Symptoms of Malignant Goiter.—*By the time malignant goiter reveals its two chief characteristics it is too late for a radical cure.* The diagnosis must be made before that time, although this is exceedingly difficult and often impossible. It, therefore, becomes our duty to prevent the disease by prophylactic measures. As yet we possess no internal remedy capable of thus preventing the disease; hence we must

inform the public that an ordinary goiter can easily become malignant. *If the thyroid gland (struma) continues to enlarge after the age of puberty in spite of correct internal treatment, it is the physician's duty in discussing the advisability of operation to call attention to the possibility of malignant degeneration taking place. If a thyroid gland (struma) begins to grow after the thirty-fifth year of life without any apparent cause, malignant change should be suspected.*

In abnormally situated, particularly intrathoracic goiters, the possibility of malignant degeneration is an absolute indication for operative treatment, because a radical operation on a malignant intrathoracic goiter can be performed with safety only in exceptional cases.

Diagnosis and Symptoms.—Early diagnosis is based on the history and on certain definite points:

(1) *The Growth of Malignant Goiter is Irregular.*—While a benign goiter occupies a definite site, which has been accurately described and stands in a certain definite relation to the surrounding tissues, we see in malignant goiter one or more nodules growing out, as it were, from the rest of the tumor and becoming more distinctly palpable.

FIG. 241.—MALIGNANT GOITER.
Shows the irregular growth of the tumor.

(2) At the same time the consistency is modified, becoming firmer in proportion to the increase of the cellular elements, and thus losing its elasticity. This is the characteristic feature. This change in the consistency never fails to attract the attention of one who has had some practice in palpating benign goiters. It must, however, be remembered that a cyst or otherwise degenerated nodule may undergo malignant degeneration, and that malignant change often follows or is accompanied by hemorrhage into the goiter. *Any goiter that is at all suspicious must be carefully examined from time to time.* Comparative palpation—*i. e.*, palpation of the different portions of the goiter—is a very useful method. Mild inflammatory symptoms are sometimes present; they differ, however, from those produced by genuine bacterial inflammations in that they are milder and not associated with the characteristic general symptoms of inflammation.

(3) On careful examination the vessels of the goiter are found to be abnormally well developed. The arteries, particularly, are larger than the size of the goiter would seem to justify. No vascular symptoms are present. There are, however, benign goiters in which the blood-vessels are better developed than in malignant goiter.

(4) The displacement of the surrounding parts is irregular, because the pressure often increases only on one side and adhesions also develop early. Special attention should, therefore, be paid to statements re-

lating to the increase of pressure-symptoms, as well as to the first signs of adhesions. These are: Changes in the voice, circulatory disturbances, slightly impaired mobility, either of the head or of the neck.

All other symptoms occur late and are for the most part due to increasing pressure. Thus, *spontaneous pain* is not an early symptom of malignant goiter. It occurs when the neoplasm has involved the external goiter capsule and the vascular sheaths. Radiating pains are complained of in the auricularis magnus, occipitalis minor and major, cutaneus colli, the supraclavicular nerves, and in the cervical and brachial plexuses. They are due in part to involvement of the capsule of the goiter and the effect of irritation; later to pressure and adhesions. When the recurrent laryngeal, sympathetic, and pneumogastric are caught in the tumor, corresponding symptoms are produced. Both active and passive mobility is diminished.

Depending on the direction of the growth dyspnea and dysphagia make their appearance, or increase if they have been present before. Invasion of the trachea and esophagus may produce the symptoms of malignant tumor of these organs. Invasion of the blood-vessels, especially the internal jugular vein, is not infrequent. If the growth of the tumor is more toward the exterior, it may make its way through fasciæ, muscles, and even the skin, and ulceration may take place.

Functional symptoms are rare, particularly symptoms of hypothyreosis, and have no effect on the prognosis. Thyrotoxic symptoms are more frequent, especially when malignant change develops in a diffuse goiter or in a goiter which apparently contains physiologic constituents of the thyroid gland in abnormal quantities.

Course and Prognosis.—The course is steadily progressive and death ensues amid the most terrible sufferings from asphyxia, metastasis or cachexia, or, more frequently, from some intercurrent disease. The course and the duration are, however, exceedingly variable. The epithelial forms—proliferating goiter, papilloma, and especially colloid goiter, with a tendency to metastasis—develop slowly, particularly the diffuse forms, and the diagnosis may be impossible without accurate and repeated observation. Metastasis occurs comparatively early and betrays the malignant character of the primary tumor. The prognosis in cases of this kind is more favorable *quoad vitam*, but permanent cure is exceedingly rare.

Treatment.—*The only method of curing malignant goiter is by early operation.* If the malignant goiter has not yet invaded the capsule the prognosis of the operation is scarcely more grave than in ordinary benign goiter. The surgeon should never consent to enucleation or resection, but should insist on doing a clean excision. In doing this there is, of course, danger of removing or injuring the epithelial bodies or the recurrent nerve. Tetania parathyreopriva must be avoided or rendered innocuous by the prophylactic administration of parathyroidin. Injury of one recurrent nerve only is not followed by serious results. If the goiter has perforated the capsule

the operation offers but little chance of a radical cure. The indications as to operation in such a case depend (1) on the presence of metastasis; (2) on the extent of the adhesions; and (3) on the general condition of the patient.

(1) If extensive metastatic growths are present in the lymph-glands or in the lungs and liver, operation should not be attempted. In the case of bone metastases, if they are multiple, operation should not, as a rule, be advised; but if the metastatic growth is solitary, operation is usually possible. We must also decide in such a case whether the primary tumor is operable. Occasionally, as for example, when there are metastases in the skull and in cases of intracapsular malignant goiter, the metastatic tumor must be attacked first. If the operation on the primary tumor offers no difficulties its operative removal may be indicated even in the presence of inoperable—*i. e.*, multiple—metastases, because the latter can be attacked later by internal medication; and because in malignant goiter the primary tumor is usually the cause of death or, at least, is responsible for most of the symptoms.

(2) Adhesions that put operation on a primary tumor out of the question are adhesions with the common carotid in elderly people, and with the large vessels in the mediastinum, as well as with both pleuræ. For the rest, all diseased tissue must be removed at the operation along with the tumor. The prognosis is unfavorably affected by extensive resection of the trachea and esophagus, or larynx and pharynx, on account of the danger of secondary pulmonary disease. Adhesions with the large vessels affects the prognosis unfavorably because it way be followed by the speedy appearance of metastases. In *epithelial tumors* which do not exhibit secondary changes the prognosis is relatively good, even if the trachea is resected. Under these circumstances if existing catarrh has been subjected to suitable preliminary treatment, and the oral and nasal cavities are kept scrupulously clean, very good results may be obtained.

(3) The patient's general condition must be taken into consideration. In the presence of severe emphysema, pulmonary catarrh, and marked congestive states which react on the heart, and particularly in the presence of any other causes that favor disturbance of the heart action, operation should not be attempted. Age in itself is not a contra-indication.

If operation is impossible, (1) symptomatic and (2) internal treatment of the goiter must be considered.

1. The symptom which most frequently requires treatment is *dyspnea*—the *danger of asphyxia*. Tracheotomy in the presence of malignant goiter is one of the most difficult operations and is often absolutely impossible; at least not without removing part of the goiter. This is particularly the case with intrathoracic goiter. Under such circumstances *evidement*, after Kocher, particularly in the case of sarcomata, may have to be considered. In view of the bad prognosis morphin medication is often preferable to a tracheotomy.

2. The pain requires symptomatic treatment.

3. Rarely a gastrotomy may be indicated on account of absolute inability to swallow.

The internal treatment for inoperable malignant goiter does not as yet offer very satisfactory results. The administration of iodothyrin and arsenic is sometimes followed by improvement or temporary arrest of the disease. Arsenic acts very well on the metastases. The specific serums have, as yet, produced no positive results. The toxins of pyogenic bacteria, which produce destruction of the goiter by suppuration, are dangerous on account of their effect on the general condition and the risk of bringing on some intercurrent disease.

ABERRANT GOITER.

Goiter formation in the accessory thyroid glands:—False aberrant goiter is a term used to denote a goiter-nodule which has become secondarily separated from the rest of the gland or goiter, usually as the result of pressure or some definite change of position, and still maintains at least a connective-tissue connection with the main tissue.

Genuine aberrant goiter is one which has developed in embryonal remains of the gland. Retrosternal, intrathoracic, retroclavicular, and preclavicular, as well as retrotracheal and retro-esophageal goiter-nodules, with very rare exceptions, are probably false aberrant goiters and belong in the section on Abnormal Positions of Goiter. The glandular remains, which are very rarely found in the larynx and trachea and compel therapeutic intervention before a goiter has developed and before they are diagnosed as goiters, are genuine aberrant goiters.

Somewhat more frequent and therefore of greater practical importance are those aberrant goiters which develop in the remains of an incompletely obliterated thyreoglossal duct. We distinguish (1) prelaryngeal or subhyoid, (2) suprahyoid, and (3) lingual goiter. The first is the rarest of all, the second somewhat less rare, and the third still less rare. These goiters develop in the same manner as genuine goiters, preferably between childhood and the forty-fifth year of life, but may be congenital and also occur in old age. They are especially apt to develop with atrophy or early goiter formation and functional disturbance of the thyroid gland, or after operative removal of the diseased gland (Eiselsberg). This interesting fact renders it necessary, whenever there is a suspicion of aberrant goiter, to make a careful examination of the thyroid glands.

Diagnosis and Symptoms.—The tumors of aberrant goiter are situated in the median line, a point of great diagnostic importance. They appear prominently on the front of the larynx and on the thyroid membrane, between the sternohyoid muscles and above the hyoid bone, forcing apart the mylohyoid and geniohyoid muscles. At the base of the tongue they are situated underneath the mucous membrane. Their consistency is almost regularly tense and elastic; their surface is relatively smooth. On the other hand, there may be several nodules, or one large and several smaller nodules, a condition that is quite characteristic of goiter

and of value in the differential diagnosis from cyst of a branchial duct. The condition of cyst, however, is rare. Aberrant goiters always have some relation with the deeper tissues or the hyoid bone, corresponding to the thyreoglossal duct. Thus, infrahyoid goiters cannot be displaced downward nor suprahyoid goiters upward (Kocher). Slight dysphagia, a certain difficulty of articulation, and an increased flow of saliva may be observed with lingual and suprahyoid goiters, but as a rule no subjective symptoms are present except in the case of large tumors, which may cause dyspnea and death from asphyxia. The clinical history is very important. The only conditions that need to be seriously considered in the differential diagnosis are cysts of the branchial ducts, salivary cysts, and lymphoma. Examination of the salivary glands (introduction of a probe into the salivary ducts), of the lymphatic system, and, especially, of the thyroid gland will suggest the probable diagnosis.

A favorable prognosis should not be given without some reserve on account of the danger of hemorrhage, asphyxia, or, finally, malignant degeneration.

The **treatment** depends on the condition of the thyroid gland and the size of the tumor. Internal treatment for goiter may be tried, especially if the thyroid is absent or its function impaired. If the thyroid gland is functionally intact excision of the aberrant goiter is the best treatment, but if there is functional disturbance of the thyroid a partial operation only must be performed on the aberrant goiter. Operation on infrahyoid and suprahyoid goiters presents no special difficulties, but the tumors are very vascular. The removal of a lingual goiter, on the other hand, is a difficult operation on account of the abundant blood supply and the position of the tumor. The first and most important requisite is convenient access to the goiter, which is best secured by means of Kocher's median division of the jaws. In the submental operation a transverse or curved incision is made and an entrance effected in the median line between the muscles.

Pathology.—The structure of aberrant struma is the same as that of genuine goiter. Whether or not the various pathologic changes peculiar to the thyroid gland also develop in these tumors it is impossible to say because the condition is so very rare, but it seems probable. The occurrence of malignant aberrant goiter, which for a long time had escaped observation, has now been definitely established.

DISEASES OF THE PARATHYROID GLANDS.

These are only beginning to be recognized clinically and the diagnosis has already been discussed in connection with functional anomalies.

Pathologically the following conditions have been found:

1. Developmental anomalies: *a*. Variation in the number of the glands. *b*. Variations in the position of the glands. *c*. The occurrence of thymus-bodies in association with the parathyroid glands. *d*. Cysts: postbronchial in connection with the parathyroid glands.

2. Diseases: *a*. Anomalies of secretion: (A) Secretion of abundant colloidal material; (B) formation of large cysts. *b*. Hemorrhages, especially in children. *c*. Sclerotic processes. *d*. Lipomatosis, proliferation of fatty tissue, which is normal in old age. *e*. Tumors: Benign tumors outside of the thyroid glands have been described by MacCullum, de Santi, Erdheim Verecely, and Getzow, and within the thyroids by Benjamin and Hulst. Malignant tumors: Carcinoma by Erdheim; sarcoma-like tumor with very marked invasion of the venæ thyreoideæ imæ by Kocher. The above-mentioned glycogen-containing goiters of epithelial character belong to the cancers of the parathyroid glands. (For a fuller consideration of the parathyroid glands, see the chapter by Dr. Charles H. Mayo in Vol. V.)

INJURIES OF THE THYROID GLAND AND OF GOITERS.

These are very rare occurrences and have no practical significance.

CHAPTER XXXIX.

THE NOSE AND ITS ACCESSORY SINUSES.

By Harmon Smith, M. D.,
New York.

ANATOMY.

The nose, externally, is a prominence consisting mainly of bone, cartilage, and integument. The upper end, beginning at the frontal bone, is known as the root; the ridge along its middle, as the dorsum; and its extremity, the point.

The bridge is formed by the two nasal bones supported by the septum, and adjoining the nasal bones below are two large lateral cartilages which converge to form the dorsum and tip, and are supplemented by several smaller cartilages which diverge backward to form the alæ. The integument adheres loosely above to the nasal bones, but firmly to

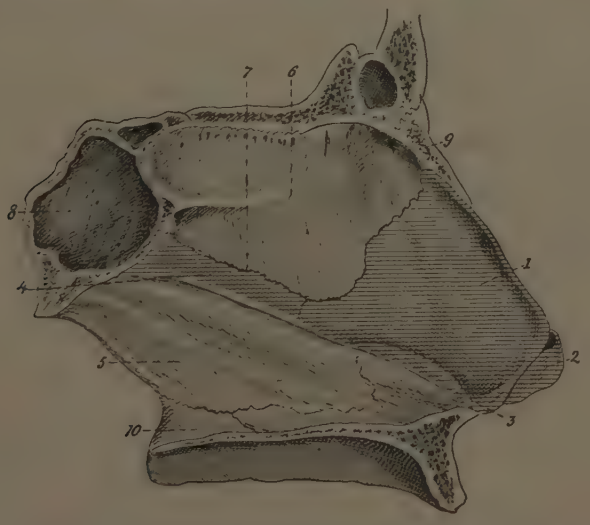


Fig. 242.—Osseous and Cartilaginous Septum of the Nose.

1, Triangular cartilage of the septum; 2, columnar cartilage, cartilage of the aperture; 3, cartilage of Jacobson; 4, supravomerine cartilage, sometimes present; 5, vomer; 6, perpendicular plate of ethmoid; 7, ethmovomerine suture; 8, sphenoidal sinus; 9, nasal bone; 10, palate bone. (Arnold.)

the tip and lateral cartilages, a fact which should be remembered in the correction of deformities by the subcutaneous injection of paraffin.

Internally, the nose is divided by a median partition, the septum, into a right and a left fossa, but owing to deviations and malformations,

either congenital or acquired, the two fossæ are seldom of equal size. The anterior part of the septum is composed of three cartilages—the triangular cartilage or cartilage of the septum, the cartilage of the aperture, and the cartilage of Jacobson. The posterior part of the septum is composed of the perpendicular plate of the ethmoid and the vomer (Fig. 242).

The roof of each fossa is formed by the cribriform plate of the ethmoid and the floor is formed by the horizontal process of the superior maxilla and the palate bone. The fossæ begin anteriorly with the vestibule, the only dilatable part of the nose, in which are numerous stiff hairs called vibrissæ. They are continuous posteriorly with the nasopharynx by the posterior nares or choanæ. The outer walls and posterior extensions of the fossæ are surrounded by the great sinuses, which communicate with them by their natural channels.

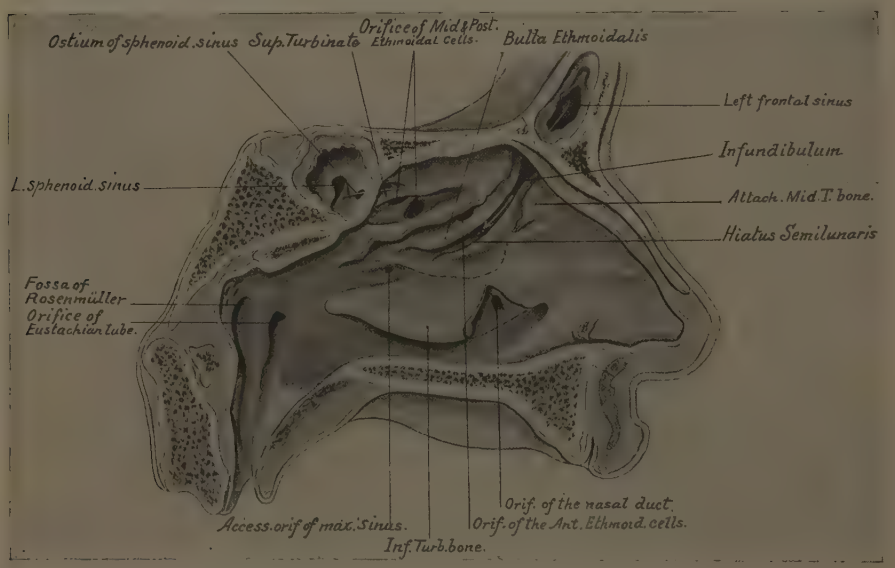


FIG. 243.—THE LATERAL WALL OF THE LEFT NASAL CAVITY.

Almost the entire middle turbinated bone has been excised in order to expose the structures and orifices situated beneath it. A piece has been removed from the anterior portion of the inferior turbinated bone. The original borders of the turbinated bones are indicated by dotted lines. The superior turbinated bone is intact. The orifices of the left sphenoidal and frontal sinuses are shown by arrows. (Schultze and Stewart.)

The outer wall of the nose is composed, above, of the superior and middle turbinate bones arising from and forming a part of the ethmoid bone, with the superior meatus between. The median portion of the outer wall represents the middle meatus, and the inferior portion the inferior turbinate with its fossa, known as the inferior meatus. The upper third of the outer wall, the roof, and the upper third of the septum are concerned in olfaction, while the remaining portion of the fossæ are for the purpose of warming, moistening, and filtering the air for its reception into the lungs.

Into the superior meatus empty the posterior ethmoidal cells and the sphenoidal sinus. The frontal sinus and the anterior ethmoidal cells open into the middle meatus through the infundibulum. The "hiatus semilunaris" is a curved furrow upon the lateral wall of the middle meatus, extending from behind and below, upward and forward, toward the infundibulum. Into this furrow, at its deepest portion, open the anterior ethmoidal cells and the maxillary antrum. The ethmoidal "bulla" is an oval prominence situated above and behind the "hiatus semilunaris." These openings can be seen only after the removal of the middle turbinate (Fig. 243). The nasal duct enters into the inferior meatus beneath the anterior portion of the inferior turbinate body.

The Schneiderian membrane lines the cavities of the nose. It is highly vascular and inseparably united with the perichondrium and periosteum, a condition which should be held in mind when the submucous septal operation is performed.

The blood supply of the septum and lateral walls of the nasal fossæ is derived mainly from the spheno- and descending palatine branches of the internal maxillary artery, also from the anterior and posterior branches of the ophthalmic artery.

Accessory Sinuses.—Although the function of the accessory sinuses is somewhat obscure, it is supposed that they contribute to the resonance of the voice, diminish shock to the nerve-centers of the brain, and afford lightness to the skull. The accessory sinuses are four in number on each side.

The *maxillary sinus* or *antrum of Highmore* is the largest, and is situated in the superior maxillary bone. It has for its roof the floor of the orbit; for its lateral wall, the external wall of the nostril; and for its floor, the roof of the mouth. It empties into the nasal chamber through the ostium maxillare, which is the lowest of the openings in the "hiatus semilunaris," and is overlapped by the middle turbinate. This sinus is not constant in size or shape.

The *sphenoidal sinus* is the next in size, is situated in the body of the sphenoid, and has its outlet in the superior meatus. It is separated from its opposite sinus by a thin lamella of bone, the sphenoidal septum, which, like the nasal septum, frequently divides the sinuses unequally and is sometimes wanting altogether.

The *frontal sinus* is found between the tables of the frontal bone and empties into the middle meatus. The roof of the orbit forms its floor. This sinus varies greatly in size and is sometimes absent.

The *ethmoid cells*, classified as anterior and posterior, are a series of small cavities surrounded by a protecting lamella of bone and situated in the body of the ethmoid bone. The anterior cells open into the middle meatus; the posterior, into the superior meatus.

Clinically it is of great importance to note the close proximity of the openings of the anterior ethmoidal cells, the frontal sinus, and the antrum of Highmore, as an infection of either the frontal sinus or the ethmoidal cells is likely to result in the infection of the antrum by gravitation of the infective secretion.

EXAMINATION.

Light.—The Argand burner with a Welsbach mantle and mica chimney, over which is fitted a Mackenzie condenser, is the present ideal office illumination. There are many electric headlights, well

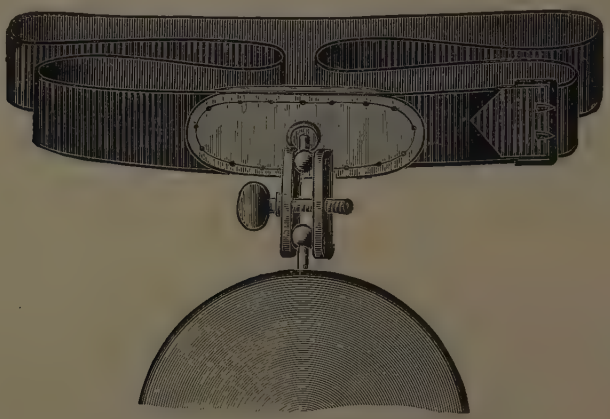


FIG. 244.—BALL-AND-SOCKET JOINT HEAD MIRROR.

adapted for use outside the office, which derive their electricity from storage batteries, and form a very necessary part of the equipment of a nose and throat specialist. The head mirror best adapted to office work

FIG. 245.—BOSWORTH'S TONGUE DEPRESSOR.

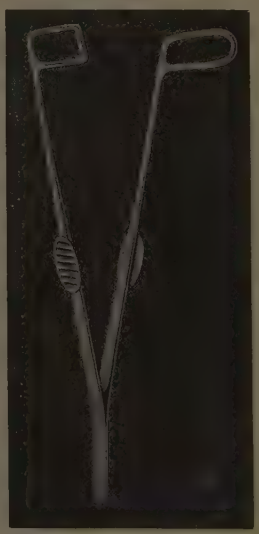


FIG. 246.—BOSWORTH'S SELF-RETAINING NASAL SPECULUM. (Fowler.)

is one with a diameter of four inches, with an aluminum back for lightness, and a large eye-hole in the center. This mirror should be connected by a double ball-and-socket joint to a headband of soft leather.

For the examination of the nasal fossæ there are many forms of nasal specula. The one most generally employed is the fenestrated speculum of Bosworth, which has the disadvantage of dilating the vestibule by means of a spring that, at times, is too strong for the natural expansion of this orifice and causes considerable pain. Hartmann's bivalve speculum is manipulated by two handles held apart by a spring, which enables the examiner to regulate the force. It also has the advantage of holding aside the vibrissæ which frequently obstruct the view when using Bosworth's speculum.

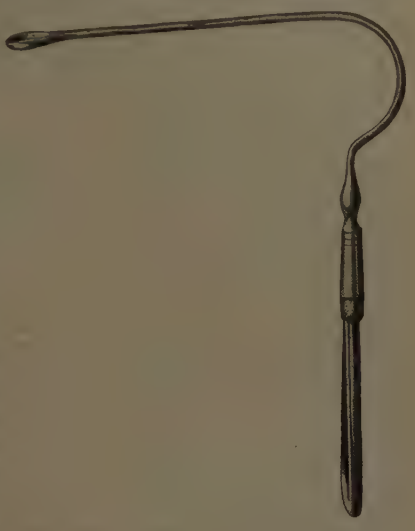


Fig. 247.—Fraenkel's Tongue Depressor.

For the examination of the pharynx and nasopharynx a tongue depressor is necessary. No tongue depressor that folds upon itself will give the stability, and at the same time the elasticity, requisite for a proper examination of an irritable pharynx (Fig. 245). A light Bosworth's depressor with a comparatively small fenestrated extremity and a well-balanced handle is one of the best instruments for ordinary pharyngeal examination. If, however, there is a contracted nasopharynx, the slim, elongated depressor of Fraenkel is better (Fig. 247). To

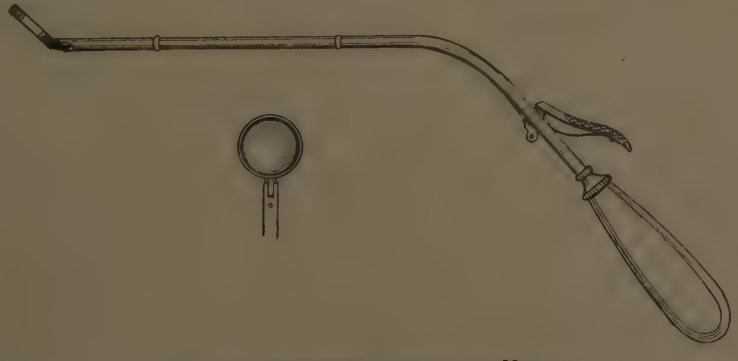


Fig. 248.—Fraenkel's Rhinoscopic Mirror.

obtain a view of the posterior nares the examiner must use a small mirror attached at an obtuse angle to a slightly bent shank. After the mirror has been warmed sufficiently to prevent moisture-formation, it is carefully passed behind the uvula and depressed so as to bring into vision the posterior border of the septum and the posterior ends of the turbinates; and likewise the presence of any growth upon the structures in the postnasal space. In England and Germany Fraenkel's rhino-

scopic mirror is almost universally employed, and has the advantage of permitting the mirror to be raised or depressed at will without disturbing the position of the shank (Fig. 244). Where intolerance to the mirror and tongue depressor exists, digital examination must be resorted to. This is unpleasant to the patient, but is frequently a material advantage to the examiner in determining the size, location, and consistency of nasopharyngeal growths. In examining the nasopharynx of children it is advisable to protect one's self against being bitten by the use of a metal or leather finger protector drawn over the index finger, or by depressing the cheek of the patient between the jaws with the index finger of the left hand so that an attempt to bite will result in self-inflicted pain.

For the method of Transillumination see page 425.

NASAL DEFORMITIES.

Nasal Fractures.—If the fractured nasal bones are immediately set and held in place by suitable splints, little or no deformity results. Several Simpson's splints, placed one over the other on both sides of the nose at the point of fracture, tightly held in place by pieces of adhesive plaster, and then moistened, offer the most satisfactory method of gaining pressure and firmness. Should the fracture be of long standing and the nasal bones be depressed upon the superior maxilla of either side, and divided from each other by a perceptible space, the patient should be placed under a general anesthetic and the nasal bones, together with the nasal processes of the superior maxillæ, broken away from their attachment by the use of a mallet and the handle of a chisel which is protected by a rubber jacket, and placed at the point where the fracture is desired. Should this procedure tend to cause too much trauma, a small incision should be made with the scalpel at the desired point of fracture, and the nasal process of the superior maxilla chiseled away from its attachment. When the two sides have been similarly treated, the nasal bones may be properly adjusted and held in place as previously described (see also Vol. II, p. 144).

Nasal Malformations Resulting from Hereditary Syphilis.—The first evidence of nasal involvement in hereditary syphilis is "snuffles," which is followed by a thick mucopurulent discharge, often streaked with blood. This stage is succeeded by one in which the septal mucous membrane is covered with tenacious crusts, under which are ulcerations. These necrotic ulcerations first attack the cartilage and later the bony structure of the septum, so that after a time the nasal bones, being deprived of their support, fall in, resulting in deformity of the nose. Another condition is where the lateral cartilages of the nose have been involved and cicatricial contractions result, which narrow the vestibule and cause collapse of the alæ.

Nasal Malformations Resulting from Acquired Syphilis.—The deformities from acquired syphilis are, for the most part, some variety of "saddle-nose," and are a sequel to the tertiary involvement of the nasal septum; although deep ulcerative processes which involve

cartilage and bone may occur in the second stage and be followed by some external deformity. In acquired syphilis the mucous membrane is first attacked with a gummatous infiltration, which soon extends to perichondrium and periosteum, and later to the framework of cartilage and bone. In the tertiary stage the necrosis begins in the framework and extends outward, involving the mucous membrane last.

The result of undermining the support to the bridge of the nose is a flattening and widening of the dorsum, with a characteristic tilting of the tip. The degree of depression varies from a gentle regular curve to a marked irregular and angular depression. The necrosis frequently extends to the lateral cartilages of the tip, and is followed by cicatricial contractions, until the entire nose is flattened on the face, with the exception of the extreme tip which projects directly outward. Ulceration may also attack the external parts and continue until the entire nose is destroyed, leaving only two bony openings to the nasal chambers. Syphilitic processes have been known to extend to the adjacent sinuses and even to the meninges.

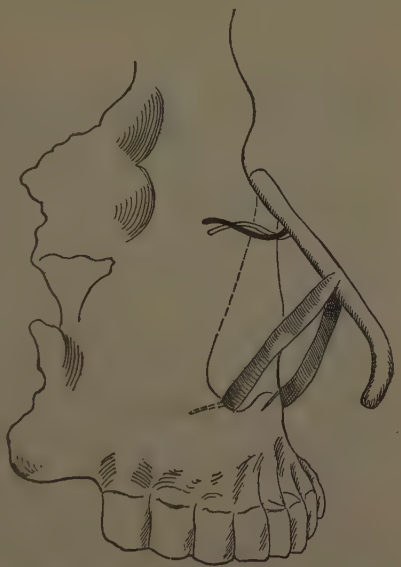


Fig. 249.—Nasal Bridge of Martin, of Lyons.

Artificial Methods of Correction.—Many artificial means have been advocated for the correction of these deformities. Bishop constructed a bridge of vulcanized rubber; Martin, one of platinum or aluminum (Fig. 249); and a later improvement upon these has been devised by Hopkins. Two methods of rhinoplasty are now described by most authors for the correction of these marked deformities—the Italian or Tagliacozzian, and the Indian (see Chapter on "Plastic Surgery").

Dr. Charles H. Knight has successfully introduced a plate of platinum under the skin in certain selected cases. It is claimed that even should the plate have to be removed, sufficient newly formed connective tissue will have been produced to give adequate support to the collapsed bridge.

The method of introduction is by making an incision along the gingivolabial fold of the upper jaw from the first molar of one side to the same tooth on the other, uplifting the tissues and periosteum until the bony entrance to the nasal cavities is reached, when ample room is secured for placing the bridge. The bridge must be moulded to meet the requirements at the time of operation, and as little pressure exerted over the tip as possible. The projecting arms should be shortened as required at the time of operation.

Keen[1] has reported the successful insertion of a silver-gilt plate to

correct a "saddle-nose" of traumatic origin. Weir[2] reports the favorable use of celluloid in restoring "saddle-nose," the plate being introduced from an incision at the side of the nose. Failure attended his attempts at insertion through incisions made within the nostrils.

ACQUIRED DEFORMITIES.

Burns.—Most unsightly deformities are frequently the result of fire or a strong acid (sulphuric, nitric, etc.) accidentally applied or thrown upon the face by some malicious person. The eschar is deep and the cicatrix firm.

"Saddle-nose."—This variety of deformity may result from traumatism, syphilis, septal abscess, lupus, leprosy, or scrofula. About 50

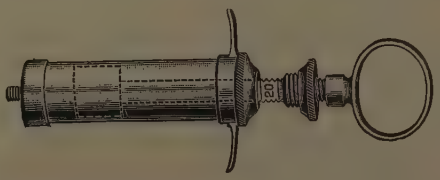


FIG. 250.—HARMON SMITH'S PARAFFIN SYRINGE.

per cent. of the cases reported have been the result of traumatism. Syphilis, acquired or congenital, has come next in frequency. The destruction of the septum, from whatever cause, removing as it does the support of the nasal bones and cartilages of the nose, will result in their sinking in and forming what is known as "saddle-nose." The depression varies greatly in depth and contour, and the skin likewise varies in its attachment to the structures beneath—at times being loose and elastic, and at other times being firmly attached and tense, which important factors determine the advisability of injecting paraffin for the correction of the deformity. Although it has been demonstrated that plates of platinum and celluloid can be used advantageously in the correction of these deformities, also that operative methods advocated by Roe and others have resulted in lessening the defects, yet no procedure has equaled in simplicity and effectiveness the subcutaneous injection of paraffin.

FIG. 251.—"SADDLE-NOSE" BEFORE INJECTION OF PARAFFIN.

The advantages of paraffin injection over other surgical methods are: 1, The correction of the deformity without resulting scar; 2, the avoidance of general anesthesia; 3, the slight reaction following the operation, permitting the patient immediately to resume his daily pursuits; 4, the simplicity of the operation, which places it within the field of all physicians exercising due regard for surgical cleanliness. The possible dangers are: 1, Abscess or slough, due to either infection or hyperinjection; 2, deformity from hyperinjection; 3, embolism—there have been reported three cases of embolism of the central artery of the retina immediately following the injection of paraffin for nasal deformity. No satisfactory solution has been submitted as to why the embolus should have taken this route in each case, or how it managed to pass through the circulation from venous reception to arterial distribution. This is a serious argument against the use of paraffin. However, in each case the paraffin has been injected toward the loose tissues at the root of the nose, instead of away from them, and toward the tip where a natural obstacle is presented to the force of the injected substance by the close union of skin and cartilage over the tip. Another error may have been committed in injecting the paraffin before it had hardened. The natural tendency of liquid substances to assume a globular form holds good in paraffin, and it is likely that these injections were made with warm paraffin. To obviate the dangers enumerated, I have devised a syringe with which the paraffin may be injected when solid (Fig. 250). The mechanical device aiding this is a thumb-screw fitted upon a coarse worm on the piston rod, which can be screwed into the head of the cylinder after the syringe is filled with melted paraffin. To advance the piston after the thumb-screw is in place, it is necessary to turn it from left to right, and by so doing the paraffin is forced out of the needle in a solid cylindrical thread. The injection should be made from above downward; a curved needle is best adapted to this purpose. Pressure should likewise be made by an assistant over the soft parts around the root of the nose, to prevent any possible damming back of the paraffin, or any return of the circulation bearing particles of the substance before they have had time to settle. The injection should be made slowly, and due care exercised in moulding the shape to

FIG. 252.—"SADDLE-NOSE" AFTER INJECTION OF PARAFFIN.

meet the requirements, and also to prevent hyperinjection. It is better to have several injections than to inject too much at any one time. The instruments, the field of operation, and the hands of the operator should be prepared as for any operation. The after-treatment consists in applying a collodion dressing over the point of entrance of the needle, and, if necessary, cold applications, although as good results seem to follow without application of cold or heat after the operation. The redness which sometimes lasts for several weeks, and even months, after the operation, can be lessened by applying ichthyol.

Broeckhaert[3] has devised an injector of paraffin which may be used in one hand, and which ejects the paraffin in a solid state. It is particularly serviceable when injecting the turbinates in case of atrophic rhinitis.

DEFLECTIONS OF THE SEPTUM.

All deflections may be said to be either traumatic, developmental, or the result of disease.

Traumatic.—Deviation of the septum from injury occurs more frequently than from any other cause, and childhood claims the greater share of these cases, although recognition of the deformity may not occur until adult life. The flexibility of the cartilage, combined with the frequent injuries to the nose, are sufficient to explain the frequent deflections resulting from trauma. In adult life blows and falls are usually more severe and produce greater injury than in childhood. The cartilages are frequently dislocated, or in some instances split, as reported by Kyle.

Developmental Deflection.—The injury may be effected *in utero* or during labor, particularly if the labor is prolonged. The nose of the infant is pressed against the bony walls of the parturient canal for some hours. The cartilages and other septal structures are soft and easily depressed and flatness of the infant's nose frequently remains for a long time after birth. Unquestionably instrumental labor results in a number of deflections and even fractures of the nasal septum. Irregular development of the teeth and adenoid vegetations are likewise cited as causes of the high arched palate which ultimately deflects the nasal cartilage. Roe found 16 per cent. of nasal deflections in the examination of 56 cadavers of newborn infants.

Disease.—Inflammation of the mucosa may be so extensive as to weaken the cartilage, particularly in purulent rhinitis of children, also in rickets and the strumous diathesis. Ulcerations of syphilis, lupus, or tuberculosis, when of a superficial character, may result in more or less deflection. Perichondritis, from whatever cause—trauma, syphilis, or diatheses—may result in partial destruction of the cartilage with subsequent deviation of the remaining part of the septum. Statistics show that deflections are more numerous among civilized than among savage races, reaching, according to Heyman, 96 per cent. in the former and only 20 per cent. in negroes and savages.

The classification of deflections is by no means simple, for many varieties exist; but for ordinary purposes they may be grouped as curved, angular, sigmoid, and double curved. A great number of modifications are found in each of these varieties. In the angular variety a marked hypertrophy of the inferior turbinal is found upon the concave side, which it is advisable to reduce before attempting the correction of the deflection.

Methods of Correction.—Ingals[5] was one of the first American specialists to advocate liberating the mucous membrane from the deflected cartilage before removing it.

The operations of Roe and Asch were for a long time the best methods known to the profession for correcting septal deviations, but have been supplanted by the superior operation known as the "Submucous Operation." Great credit is due to Freer[6] for developing the technic of this operation and it is described as follows: Powdered cocain is applied to both sides of the deflection, followed by adrenalin solution. The initial incision is made vertically along the angle or summit of the cartilaginous

Fig. 253.—Freer's Knives for Submucous Resection of Septum.

deflection and through the mucosa only. This incision is joined by a horizontal one nearly at right angles to it, and beginning posteriorly upon the septum about ¾ inch from the lower extremity of the first, and is brought forward along the bottom of the septum until it has passed the anterior margin of the deflection. These incisions represent an inverted T and are made with knives especially designed for this work (Fig. 253).

The next step is the elevation of the flaps by the use of a thin, dull-edged dental spatula (Fig. 254), and the mucosa is elevated as far back as the deviation reaches. When the entire deviation is bared of mucosa a slit is made through the cartilage as far forward as the anterior flap will permit, care being taken not to cut the mucous membrane of the opposite nostril. This may be avoided by placing the little finger of the left hand in the nostril and by it detecting the pressure of the knife before it can penetrate. Through this incision the blunt dental spatula is pushed, and the mucous membrane of the concave side is separated from the cartilage. When this is accomplished, Ingals' pointed cartilage knife is placed under the cartilage and it is severed along its entire

base. This liberates the cartilage in front and below, and it is then seized with forceps and severed from behind and above with a small angular knife. The projecting bone of the vomer is pinched off with Grünwald's forceps. The bony ridge below the cartilage may be treated in like manner or smoothed down with a dental burr. The flaps are placed in apposition and a moderately tight packing of strips of lint rubbed full of subnitrate of bismuth is applied. The dressing is pulled out gently from day to day until all is removed.

Ballenger's operation differs in no material way from Freer's except in the use of his own swivel knife for the removal of the deflected cartilage.

To eliminate a number of unnecessary instruments and to employ a method that utilizes many of the salient points of all the operations, the following is a method suggested by myself:

FIG. 254.—FREER'S DULL DENTAL SPATULA.

FIG. 255.—HURD'S SPECULUM.

The nose is first cleansed within and without with some alkaline solution and powdered cocain applied to both sides of the septum until complete anesthesia obtains. Adrenalin solution (1 : 1000) is then applied on pledgets of cotton packed tightly in the nostrils so that pressure aids its action in driving the blood from the mucosa. An incision is made with a small scalpel, beginning as high up on the septum as the vestibule will permit and just internal to the junction of the skin and mucous membrane, and is carried down perpendicularly to the floor of the nose and outward for half the distance from the septum to the outer wall. This incision is one advocated by Yankauer, and is always made upon the side of the convexity and carried only through the mucous membrane and perichondrium. The elevation of the mucous membrane and the perichondrium is now begun with the sharp elevator of Freer, and after being thus started is completed with his blunt elevator. With this large incision ample room is obtained in which to work after the elevation is completed, and the mucous mem-

brane is held aside with the speculum devised by Hurd for this purpose (Fig. 255). The next step is to curet through the anterior part of the cartilage with a sharp spoon curet. This is much safer than attempting to cut through with a scalpel, as the nose of the curet will push back the mucous membrane of the opposite side without injury. The direction is vertical and along the line of the first incision. After gaining an opening the sharp elevator is introduced to start the mucous membrane, and then the Freer blunt elevator is employed to continue the elevation beyond the deviation. After the entire septum involved in both cartilaginous and bony deviation has been freed of mucous membrane, the swivel knife of Ballenger is introduced and directed upward and backward, then downward to the vomer, and lastly forward, cutting as close to the crest as possible. One is frequently able to remove almost the entire deviation by this method, but in any case of deviation sufficient to warrant the operation some bone is involved and requires a bone-cutting forceps to remove it. The fenestrated forceps of Grünwald are very efficient, also those devised by Hurd are particularly suitable for the removal of the nasal crest. Too much breaking and tearing should be deplored, as unnecessary trauma results. Cutting forceps are the best. After the cartilage and bone are removed the two sides of the mucous membrane are brought together and gauze dusted with bismuth subnitrate is packed in the nostril, as suggested by Freer. Some reaction follows, but this may be ameliorated by cold compresses applied externally. The packing should be removed in forty-eight hours and is not replaced if union has begun in the line of the incision. The results are remarkably good when proper care is exercised and the cases selected are at all suited for the operation. In some instances the mucous membrane is so thin over the apex of the deformity —being frequently associated with ulcers at this point—that it seems unwise to attempt this method of reducing the deflection. Since Krieg first advocated the submucous resection, however, much has been done to facilitate the technic and enable the operator to expect a good result.

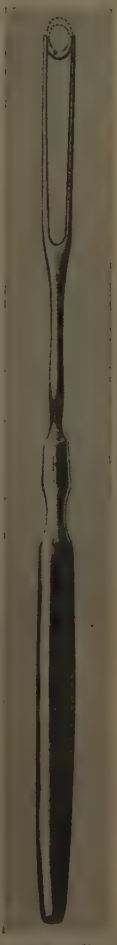


FIG. 256.—BALLENGER'S SWIVEL KNIFE.

DISEASES OF THE NOSE AND NASAL CAVITY.

Rhinitis.—Hypertrophic.—The surgical treatment of hypertrophic or hyperplastic rhinitis consists in reducing the enlarged turbinates by cutting out a V-shaped piece from the most pendulous portion with

a fenestrated cutting forceps or by causing a cicatricial contraction by the application of the galvanocautery applied along the edge of the enlarged turbinate. The chemical cautery may be used in like manner with less resulting reaction.

Atrophic.—Atrophic rhinitis also is frequently treated with the stimulating effects of the galvanocautery lightly applied. The latest surgical treatment of atrophic rhinitis is the submucous injection of paraffin over the area of the inferior turbinate. This injection fills in a part of the unnatural space resulting from the atrophy, diminishing the ozena and stimulating the natural secretions.

Abscess of Septum.—Abscess of the septum never develops spontaneously, but is frequently the result of traumatism and is often metastatic. Most frequently it is unilateral, but it may be bilateral. The submucosa is usually the confining membrane, but the perichondrium may also be involved, which complicates the case. Early and free evacuation of the pus is usually all that is necessary to overcome the difficulty.

Epistaxis.—Any hemorrhage from the nose may be called epistaxis. It may vary from a few drops to a continuous flow, endangering life. The causes may be either local or systemic.

Local.—The most common local cause is traumatism, whether accidental or operative, and it occasions probably one-half of all the hemorrhages from the nose. Ulcerations, whether syphilitic, tuberculous, or perforating, are responsible for a great many hemorrhages, particularly if the ulceration is near the junction of the anterior cartilage of the septum with the skin and just within the vestibule.

Systemic.—Hemophilia is occasionally met with in operative procedures, but the condition is rare and many hemorrhages are wrongfully attributed to hemophilia as a cause, when it really does not exist. It is not definitely known whether this condition is due to the absence of one of the coagulative principles of the blood or to a local vasomotor paresis, but when encountered it is of serious moment. It runs in families, and it is always advisable to inquire into the history of any prospective operative case as to whether there is an individual or family tendency of this nature. There is a peculiar epistaxis which occurs rarely in females about the menopause, called "vicarious menstruation"; which, if not too excessive, may be considered favorable rather than otherwise. One fatal case is reported by Fraenkel. Epistaxis frequently occurs during pregnancy, in the beginning of typhoid fever, in leukemia, purpura, scurvy, diphtheria, scarlet fever, variola, malaria, etc. Likewise in cardiac, renal, and hepatic diseases.

Treatment.—Examination should ordinarily reveal the bleeding point, to which the operator should direct his attention. Local applications of hydrogen peroxid on pledgets of cotton will frequently stop a mild hemorrhage. Adrenalin solution (1 : 1000) is most efficacious and stops temporarily, at least, the majority of nasal hemorrhages. Before resorting to any other means the mucous membrane should be cocainized, which may itself stop the hemorrhage. Nitrate of silver

applied fused on a cotton applicator has proved successful in many instances; while tannic and gallic acid, compound alum powder, and powdered matico blown upon the surface with an insufflator will frequently result favorably. It sometimes becomes necessary to tampon the anterior as well as the posterior nares. The best tampons for the anterior nares are the Simpson splints (Fig. 257), made of Bernay's sponge, which when moistened swell to eight times their size and exert sufficient pressure to control the hemorrhage. The postnasal tampon is more difficult of application and is made of a strip of gauze tightly rolled until it is about ½ inch in diameter and 2 inches

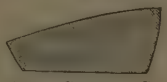


Fig. 257.—Simpson Splint.

long. This is tied in the middle with a heavy, twisted silk cord and the surface is covered with vaselin to prevent irritation when drawn into the nasopharynx. A Bellocq's sound (Fig. 258) is passed through the nares, carrying a cord which is tied to the one attached to the tampon. The tampon is then forcibly drawn up into the choanum or posterior naris of the bleeding side. The mere placing of the tampon in the nasopharynx is insufficient—it must be tightly drawn into the postnasal space. Twenty-four hours, or at most thirty-six, is as long as it should be permitted to remain, as it creates irritation, is extremely unpleasant, soon becomes septic, and endangers the Eustachian tube.

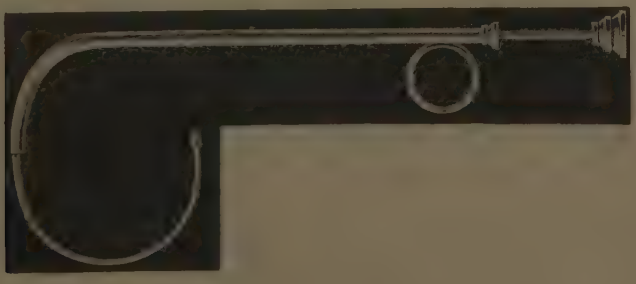


Fig. 258.—Bellocq's Cannula with the Spring Carrier Projected. (Fowler.)

Constitutional treatment should be given to those afflicted with diseases accompanied with epistaxis. Iron, ergot, thyroid extract, and adrenalin are the most beneficial internal medicines for controlling epistaxis.

Foreign Bodies.—Nearly every conceivable body of sufficiently small size to enter the nasal vestibule has been found in the nose. Beans, buttons, small shells, seeds of all kinds, screws, tacks, etc., have all been removed from the nostrils. Pledgets of cotton, tablets of medicine, and even a cannula, have been removed from the nose years after having been placed there. The soft substances can usually be syringed out with a warm normal saline solution, but hard objects

become embedded in the tissue and encrusted with secretions, so that anesthesia and the forceps or curet are required to extract them.

Rhinoliths are rarely met with. They appear to be composed of organic matter surrounded by calcareous concretions and are embedded in the mucous membrane. They are most frequently found on the floor of the nose and are detected with the probe rather than with the eye.

Parasites.—The ordinary house-fly and the Texas fly, which produces the screw worm, are the most fertile sources of production of nasal parasites, although gnats and other insects invade the nose. In South Africa the tsetse fly sometimes produces alarming, if not fatal, inflammation of the nasal mucosa. The symptoms due to the American fly are excessive inflammation with high temperature, bloody, purulent discharge, and maggots in the material blown from the nose. In 1884 Mackenzie suggested the injection of pure chloroform, and this has been demonstrated to be the most effective agent for their destruction.

Syphilis.—Syphilis of the nose may be primary, secondary, or tertiary, as in any other location upon the body. If primary, the small elevated papule may escape observation unless evidence is obtained of other local manifestations. An indurated ulcer extending over any period of time upon the septum, alæ, or turbinates, with swelling of the sublingual and submaxillary glands, and a coincident cutaneous eruption, should be sufficient evidence to raise the question of syphilis. Mucous patches and ulcerative processes, either shallow or deep, involving mucous membrane only or including cartilage and bone, are evidences of the secondary period, but this condition merges so gradually into the tertiary that, clinically, the last part of the secondary may be considered the same as the first part of the tertiary. Destruction of bone and cartilage in the secondary stage follows the involvement of the mucous membrane; but in the tertiary stage the bone and cartilage is first involved, followed later by ulceration of the mucous membrane. The symptoms of the primary stage are those of any ulceration of the mucous membrane, and the site of the ulcer is usually upon the septum or alæ, within easy reach of the finger or instrument. There is little if any pain, but some coryza and nasal obstruction. Local treatment avails practically nothing and immediate constitutional treatment should be instituted. The symptoms of the secondary stage are but the exaggeration of the primary, more coryza and more obstruction, accompanied with slight fever. In the latter part of the secondary stage the symptoms assume greater severity and the patient suffers from dull headache, perverted olfaction, and a peculiar phonation. The mucous membrane is red, swollen, and frequently edematous: the discharge becomes thicker and has a fetid odor, later becoming purulent and slightly tinged with blood. Mucous patches occur, over which is spread a yellowish secretion, which if wiped away leaves a raw surface which does not bleed easily. The tertiary period develops after some years—from six to twelve,

usually—with an intermediary period of comparative quiescence. The mucous membrane is a purplish red or may become pale as time wears on. Pain may be present and frequently there is considerable neuralgia. The sense of smell is lost and crusts form upon the mucous membrane. The discharge is very offensive and is uninfluenced by disinfectants. The ulcerative process spreads, forming large greenish scabs mixed with necrotic shreds. The bone is necrotic and when touched with the probe gives the sensation of contact with emery paper. Fragments of bone can be detached until the whole vomer or parts of the nasal floor come away. The entire septum melts away, followed by a sinking in of the dorsum, producing the "saddle-nose"; or if the process is not controlled the entire nose may slough off, leaving two bony holes entering the skull. Unsightly cicatrices are formed, giving a most hideous expression to the face. The treatment should be mainly constitutional, but unquestionably a great deal can be accomplished locally by the free use of diluted hydrogen peroxid, either as a douche or on pledgets of cotton. Fused silver nitrate may be applied to the ulcers or the galvanocautery if granulations spring up too rapidly. Detached bone should be removed and deep-seated bony necrosis should be cureted or operated on by the gouge and chisel. In the secondary and tertiary stages too much stress cannot be laid upon the internal use of iron. The subject of deformities will be treated in the chapter on Plastic Surgery.

Tuberculosis.—In view of the constant exposure of the nasal mucous membrane, infection is extremely rare. As secondary to previously existing tuberculosis in the larynx or lungs, it is more common. In this manner it is transmitted by either lymphatics, blood, or expectorated matter which may be blown into the nasopharynx, thence through the nose. The predisposing causes are those constitutional and hereditary conditions predisposing to tuberculosis in any locality; also bad ventilation in the nasal cavity due to exostoses, etc., ulcerated surfaces upon the septum, and vocation.

The symptoms are at first slight and may be those found in many conditions of the nose, tending to block the passage and excite increased mucous secretion. At first there are small nodules about the size of a millet seed, which are hard to the touch, later softening and breaking down, forming a small ulcerative surface. As the mass is robbed of its vascular supply by the formation of a fibrous protective sheath the center undergoes liquefaction necrosis, which ends in caseation. The absence of pain, the pallor of the surrounding tissue, the character of the ulcer, the elimination of specific history, and the slow process of the disease are the important factors aiding one to a correct diagnosis.

Treatment.—Free curetment and the application of lactic acid (50 per cent.) should be first resorted to. If the lesion has to be removed entirely an incision should be made as free as for malignancy, so that the entire area, with the protective inflammatory products thrown out by nature, may be removed entirely. Equal parts of guaiacol and castor oil or menthol and olive oil will frequently allay the pain.

Rhinophyma.—When acne rosacea becomes exaggerated to what may be called its third stage, an increase in the connective tissue takes place and the tip and sides of the nose become converted into a lobulated mass so great as to form one or more pendulous tumors, which hang down over the lip. The condition is known as rhinophyma. The whole mass is deep red or purple in color, with many open-mouthed sebaceous glands. Digestive disturbance, from whatever cause, is the underlying condition. Strong drink or tea, producing gastric catarrh and reflex dilation of the facial vessels, is frequently responsible for the condition. Keen reports a very interesting case of rhinophyma upon which he operated and obtained an excellent result. Besides

FIG. 259.—RHINOPHYMA: APPEARANCE BEFORE OPERATION. (Keen.)

cutting away with an elliptical incision the major portion of the growth, he subsequently shaved off remaining fragments of the skin, but not through it. This procedure was followed by slight hemorrhage and by scarcely noticeable cicatrices. After the removal of these growths the hemorrhage can be controlled by adrenalin. It is well to attempt skin-grafting as a means of preventing unsightly cicatrices.

Rhinoscleroma.—Rhinoscleroma is an exceedingly rare condition, particularly in the American born. Only about 600 cases have been known to exist since first described by Hebra and Kaposi. Southeastern Europe furnishes the greatest number, and up to 1894 only 2 cases had been reported in the United States, according to Jackson.

Since that time more have come to light, but they have usually been in foreigners. C. W. Allen[8] reports 2 cases, 1 having been under observation fourteen years, thus demonstrating the extremely slow growth of the tumor. Treatment is unsatisfactory.

Tumors and Cysts.—Nasal Polypus.—Under this head may be classed the myxomata, the myxofibromata, and the mucocele, as all are similar in their structure, have similar symptoms, and are practically treated in the same manner.

Etiology.—Several theories exist as to their cause; the first was advanced by Boerhaave, that they originated from irritation caused

FIG. 260.—RHINOPHYMA: APPEARANCE AFTER OPERATION. (Keen.)
The corrugated condition of the skin is more marked than on the nose itself.

by the retention of secretion in a mucous follicle, which from the force of gravity and pressure from behind developed a pendant pouch filled with mucin, etc. Woakes claims that nasal polypi are secondary to purulent or inflammatory disease or necrosis of the middle turbinate bone or ethmoid cells. Bosworth, Casselberry, and Grünwald attributed nasal polypi to some previous ethmoiditis. In clinical experience we frequently find them associated.

Polypi are gray in color, streaked with blood-vessels, and indent on pressure. The tumor may be single or there may be hundreds clustered together. Pathologically, these tumors differ only in the percentage of fibrous elements, the myxofibroma having the greatest

amount and the mucocele the least. They all contain a small amount of fibrous tissue, are poorly supplied with nerves, and in the majority of instances can be removed without pain, even though no anesthetic be used. The symptoms vary in proportion to size, location, and number of the tumors. There is nasal stenosis with attendant loss of nasal resonance. There is also postnasal dripping and the discharge is offensive only when some necrosis or other associated condition accounts for it. There may be some eye-symptoms from pressure upon the nasal duct and the number and size may be such as to occasion facial deformity. Asthma, laryngeal cough, and other neuroses are frequently caused by the presence of a polyp high up in the nasal chamber. The sense of smell is frequently impaired when there is pressure over the olfactory region.

Treatment.—There is but one method of treament—removal. The cold-wire snare is the best instrument. Wright's nasal snare is well adapted to this purpose, but any snare will meet the requirements (Fig. 261). If the tumor is sessile there is apparently more likelihood of its ultimately becoming sarcomatous. The polyp may return after removal, but it is inexpedient to attempt the use of caustics on

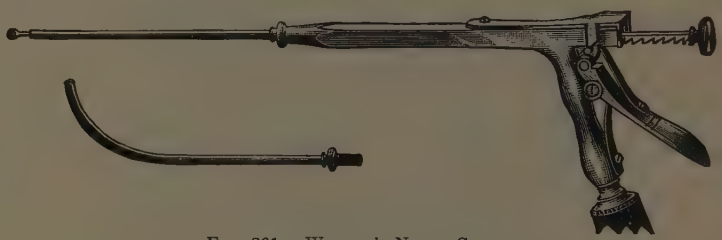


Fig. 261.—Wright's Nasal Snare.

the stump. If ethmoiditis or irregularities of the nasal passage exist they should be corrected. The myxofibromata are virtually the same from a clinical standpoint, while the mucocele is in reality a retention cyst, having its origin in the mucous glands. Both the latter are to be treated the same as a pure myxoma.

Fibromata.—Fibromata are seldom found in the nasal fossæ, though they are frequent in the nasopharynx. These tumors are usually round, smooth, and symmetric, though variations have been reported. They should be removed.

Papillomata.—Papillomata occur more frequently than fibromata. They vary in size from a pea to a filbert, are warty in character, are always attached to the inferior turbinate or the septum, and are frequently multiple. They appear pink or red, are soft to the probe, bleed readily, and are freely movable. They are to be diagnosed from angiomata and should be removed by the snare and the base cauterized.

Cystomata.—Cystic changes in old polypi are of frequent occurrence, and cystic dilation of the normal lymph-channels is usually found in adults and may develop in any situation (Knight). The same author reports a case in which the cyst occupied the floor of the

nose in the left vestibule, which was cured by free incision and packing the cavity with gauze. This should be the method pursued in any case of cyst.

Angiomata.—Angiomata are rarely found within the nasal cavity. Highly vascular tumors of other varieties are frequently mistaken for angioma and treated as such, although differing greatly pathologically. In angioma the walls of the vessels become dilated and are curled and intertwined. Their most frequent location is the septum, though they may appear upon any other structure. Probing will occasion hemorrhage and they are frequently spoken of as the "bleeding polyp of the septum." They should be snared off with a galvano-cautery snare, which almost insures non-recurrence.

Osteomata.—Osteomata are rare and generally they have their origin in the maxillary sinus. They may, however, grow from the periosteum of either septum or turbinates. Their diagnosis is easy and the treatment is removal.

Chondromata.—Chondromata are extremely rare and are frequently confused with ecchondroses, which are hyperplastic growths frequently seen on the surface of the cartilage of the septum. A chondroma is a growth of early life, is single, and may spring from the perichondrium in any location. The symptoms and treatment are the same as for osteomata.

Sarcomata.—Sarcoma is rarely primary in the nose, but usually has its origin in some of the adjacent sinuses. It is sometimes mistaken for myxoma, and not until severe hemorrhage follows removal or a speedy return of the growth occurs with exaggerated symptoms is the operator's attention drawn to the possibility of its true character. Ordinarily nasal sarcomata are of slow growth until interference is begun, when they develop rapidly. They are more common in early life and are rare after fifty. Sarcomata of the nose are classified, as elsewhere, into small round-celled, spindle-celled, giant-celled, and melanosarcoma. There may be in addition mixtures of non-malignant with sarcomatous growths, as myxosarcoma, adenosarcoma, etc. Usually a sarcoma has more than one kind of cell in its structure and is classed according to the predominating cell.

Symptoms.—Pain is not a prominent factor until the cavity of the nose is filled or the sinus where it originates is fully occupied. The pain is due to pressure. Hemorrhage seldom occurs until the growth has reached some size, when it becomes vascular and ulcerates; or unless some injury occurs which ruptures its outer membrane. Obstruction of the nose is probably the first intimation given the patient of something being abnormal. There is profuse catarrhal discharge, becoming mucopurulent and later bloody as the growth increases. If the tumor begins in the sphenoidal sinus or in the maxillary sinus there is probability of the eye being pushed forward and outward, giving rise to the so-called "frog-face."

The late symptoms are very distressing, the most prominent being disfigurement, pain, fetid discharge, and frequent hemorrhages. A

correct diagnosis is obtainable by microscopic examination of a section carefully removed, but the evidence of the microscope, however conclusive, should not lead one to disregard clinical symptoms.

Treatment.—Although we know that early and complete removal may eradicate the disease, yet one should be guarded in assuring the patient that eradication is certain, as no operator can determine the extent of sarcomatous growths until all the adjacent sinuses have been explored. The only possible treatment is the thorough and extensive removal of the upper jaw and all the neighboring diseased tissues, including any nerves protruding into the infundibulum. In inoperable cases Coley's fluid may be tried.

FIG. 262.—SARCOMA IN THE LEFT NASAL PASSAGE. (Bliss.)

Wounds.—Punctured wounds seldom occur in the nose and should be treated as any other punctured wound. It should never be forgotten that the brain may be injured by such a wound and require a serious intracranial operation.

Incised wounds are more frequent and the cartilages, if involved, should be sutured. If the cartilages are not involved the edges may be coapted and held together with adhesive plaster. Care should be exercised in approximating the edges, especially when the nostrils are involved, as irregularity of apposition results in deformity. The high vascularity of the nose encourages detached pieces to grow again if immediately replaced and held by a light collodion dressing.

Contused and lacerated wounds require the same care as elsewhere, and if there are detached pieces they should be reapplied and dressed with hot normal saline solutions.

Injuries.—Fractures.—These are commonly considered as frac-

ture of the nasal bones, but severance of the nasal bones or cartilage and bony septum are also to be regarded as fractures. Many times simple dislocation is confounded with fracture. Fractures are ordinarily not dangerous to life; but if they involve the base of the nasal bones they may become so if detached pieces penetrate the cribriform plate and enter the brain. Inflammatory conditions and sepsis are apt to follow. The nasal process of the superior maxilla and the vomer are apt to be involved when a blow of sufficient force has been received to fracture the nasal bones at the root of the nose. The fracture is always by direct violence, is frequently comminuted, and is generally compound, through laceration of either skin or mucous membrane.

Surgical Emphysema.—This is most marked following fracture of the comminuted variety. The eyelids and cheeks become puffy and give the characteristic crackling sound upon palpation. In many instances the emphysema obscures the fracture. One should not, however, be misled by either emphysema or induration, as emphysema is a prominent symptom of fracture, and is produced by the escape of air from the nose in the act of sneezing, coughing, or blowing, and gains entrance into the adjacent tissues through some abrasion in the mucous membrane. A correct diagnosis of the seat of fracture, its character, and extent, is imperative, even if a general anesthetic is required to obtain this knowledge.

Treatment.—Whether the patient is seen immediately or after the swelling has abated it is essential to have the case completely under control in order to overcome properly a fractured nose. A general anesthetic is therefore advisable. To reset the fractured bones, place them in their former position, and to hold them there is the object desired. One of Freer's periosteal elevators wrapped with cotton is an excellent instrument for passing into the nasal chambers and pressing the depressed bones outward. The fingers are sufficient for external manipulation. Some support is necessary from within to preserve the integrity of the parts, and a thin, hollow nasal splint or one-half of a Simpson splint is all that is required. Daily removal of all packing or splints and free irrigation with hot saline solution is very essential for the prevention of sepsis in adjacent sinuses.

Rhinorrhea.—Nasal rhinorrhea is rare, obscure, and easily mistaken for cerebrospinal rhinorrhea. In both conditions there is an escape of a thin watery discharge in more or less profuse quantities. The nasal mucosa is the source of the discharge in the one, while the arachnoid space produces it in the other. The etiology of the nasal type is somewhat obscure, though one finds a well-marked neurotic temperament in those cases in which it occurs.

In cerebrospinal rhinorrhea the history of injury, usually a fracture of the skull along the cribriform plates permitting the exit of cerebrospinal fluids, aids in making a diagnosis. The flow is continuous, not stopping during sleep, and there is no variation in the amount of the discharge during the day. There are no prodromal symptoms, such as sneezing or nasal irritation. The discharge is invariably from one

side. Chemical examination shows an absence of mucin, a substance which is always found in nasal rhinorrhea; and the discharge reduces Fehling's solution, which is not the case with the fluid in nasal rhinorrhea. (See chapter on the Surgery of the Head, p. 125.)

Treatment affords but little relief for nasal rhinorrhea, but attention should be directed to any constitutional disturbance existing. The local use of atropin (gr. 1 to 4 oz. of water used as a spray) and of adrenalin (1 : 10,000) has given temporary relief.

Carcinoma.—Intranasal carcinoma is comparatively rare and, as a rule, occurs only in patients over forty. Kyle advances the theory that physical decline favors the development of carcinoma, while physiologic activity favors the development of sarcoma.

Symptoms.—Lancinating pain is an early symptom, with nasal obstruction and a discharge of a characteristic odor and color. Should the growth extend to the orbit or to the ethmoids or sphenoids, there will be disturbance of vision and exophthalmos. There is but little glandular involvement, unless it is secondary to carcinoma elsewhere. Cachexia is present late in the disease. The microscope is the main factor in diagnosis, though the appearance, age of the patient, and the clinical symptoms are valuable adjuncts. If the tumor is far advanced interference is contra-indicated. The prognosis is very grave, practically hopeless.

Treatment.—If recognition of the character of the growth is made early, complete removal is the best method to be pursued. If the growth has advanced to ulceration and there is glandular involvement or if it is secondary to carcinoma elsewhere, operative interference should not be considered.

DISEASES OF THE ACCESSORY SINUSES.

In **acute** or **catarrhal inflammation of the accessory sinuses** there are present so many features common to all that they must be considered under one head before discussing each cavity separately. A turgescence of the nasal mucous membrane in connection with a coryza may dam up the natural opening of the sinus and produce an acute catarrhal condition in the latter. Such conditions are frequently encountered in the course of the exanthemata, typhoid fever, diphtheria, erysipelas, and particularly in influenza. Whether the involvement of the sinus is due to the extension of the inflammation by continuity or whether there is a direct infection from the organism peculiar to the disease, has not been definitely determined. Traumatism frequently occasions acute inflammation of the sinus, and it is particularly directed to the maxillary and frontal sinuses, the others being somewhat protected by their position.

Symptoms.—Pain is almost always present upon the side affected, accompanied with swelling and sensitiveness on pressure, and frequently with edema of the overlying structures. The location of the pain materially aids in determining the sinus involved. In ethmoidal

disease the pain is usually referred to the bridge of the nose and to the eyeball. In sphenoidal disease the pain is in the back of the head and between the eyes. Supra-orbital pain, however, is not a definite symptom of frontal-sinus involvement, as we frequently find it accompanying antral disease. A discharge of pus from one side in an adult, affected by the position of the head and intermittent in flow, is indicative of sinus disease; but bilateral sinusitis is by no means infrequent and the same conditions present themselves on both sides. The location of pus is also an indication as to which sinus is involved, though the pus from the frontal, anterior ethmoidal, or maxillary sinus may lie in

FIG. 263.—PANSINUSITIS ON LEFT SIDE. (Caldwell.)
Note numerous septa dividing the frontal sinus into separate compartments on right side.

about the same location, namely, the middle meatus, under the convexity of the middle turbinate. The color of the discharge from the antrum is a distinguishing feature, being of a light yellow or canary color.

The Maxillary Sinus, or Antrum of Highmore.—The position of this cavity, together with its size, makes it appear more prone to infection than any of the other sinuses; but modern research has shown that the ethmoidal sinuses are more frequently infected than the maxillary. The natural opening for draining this cavity is so high up that the sinus in question forms a pocket from which pus can escape only by artificial aid or by the movement of the cilia. This opening

frequently varies in position and may occasionally be found above the level of the orbital floor. Another factor tending to induce infection is the projection of the roots of the teeth into or near the antrum, so that caries of the roots is able to infect the sinus.

Symptoms.—Empyema of the antrum may be acute or chronic, and is usually the consequence of a carious tooth or of an infective rhinitis or ethmoiditis—though there are cases recorded in which the empyema followed traumatism or was the result of a foreign body in the cavity. The symptoms in acute empyema differ but slightly from the chronic—pain, tenderness, and swelling being more apparent in the former. The pain may be in the teeth, upper jaw, and nose, or it may be confined to the frontal region and radiate over that entire side of the head. Tenderness may be elicited by pressure over the canine fossa and the point of exit of the infra-orbital nerve, and close

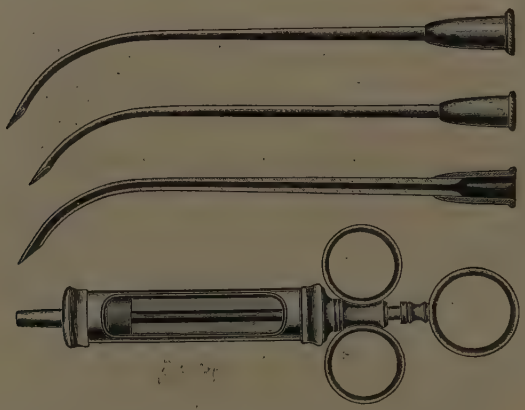


FIG. 264.—ABRAHAM'S ANTRUM NEEDLES AND SYRINGE.

observation will occasionally demonstrate swelling over the jaw of the affected side.

Lacrimation and photophobia are the two diagnostic points most frequently present, and congestion of the conjunctiva may also be observed. Slight elevation of temperature co-exists. If the teeth of the upper jaw be gently tapped with the tongue depressor a marked tenderness will be noted upon the affected side. If these symptoms fail to confirm the diagnosis, recourse may be had to catheterizing the sinus through the ostium and washing out the pus or by entering the cavity through the inferior meatus with an antrum trocar. Myles' trocar has proved of great value, as a cannula is left in place through which the antrum may be irrigated. Abraham's antral set is particularly adaptable to gaining entrance into the antrum through the nose, both for diagnosis and subsequent drainage (Fig. 264). The puncture should be made in the inferior meatus, well up under the inferior turbinate and at the juncture of the anterior and middle thirds of the cavity. Care should be exercised in the direction given the

PLATE IV.

FIG. 1.—TRANSILLUMINATION EFFECT IN A NORMAL CASE.

FIG. 2.—TRANSILLUMINATION EFFECT IN SINUSITIS OF RIGHT ANTRUM OF HIGHMORE.

trocar, as it will enter the cheek if directed too far anteriorly, and the orbit if too far superiorly.

Transillumination.—Transillumination of the sinuses is an important aid in the diagnosis of empyema. It was first used by Voltolini and was developed by Heryng. Since then numerous investigators have added to the efficiency of the procedure. The diagnosis of empyema by transillumination alone is not accepted by modern rhinologists. Normal sinuses will transmit the light with a certain intensity, which is greatly reduced by the presence of pus, but which may be intensified when a mucocele or cyst has thinned the antral wall by pressure. The examination should be made in a dark room and the light should not be very bright, as a light can be increased in intensity to penetrate any contained fluid. A darkened area can be observed over the affected side and the patient will notice the absence of light reflex in the eye of the same side. Certain sources of error must be held in mind in determining the value of the examination—as the imperfect symmetry of the two sides—for the smaller the cavity the less light is transmitted. Thickened lining membrane or thickened sinus walls will likewise diminish the intensity of the reflex. Dental plates obstruct the light and should be removed before transillumination. Knight reports a case of suppurating dentary cyst that was very confusing in making a diagnosis. There are many lamps now in use for transillumination, all of which will serve the purpose. It is not necessary to have a high-power light, as that would counteract all the advantages of the method. Transillumination is not so serviceable in the diagnosis of empyema of the other sinuses, but should be used upon the frontal sinus, for here it is an aid in diagnosis (Plate IV.).

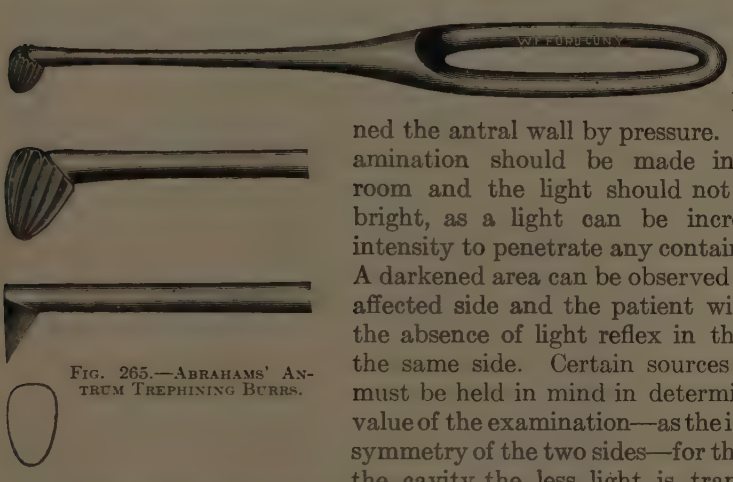


FIG. 265.—ABRAHAMS' ANTRUM TREPHINING BURRS.

Treatment.—After the diagnosis is established the question of treatment arises. In considering the method of treatment three points must be determined: 1. Is a diseased tooth the cause of the trouble or is it entirely of nasal origin? 2. Is the infection of recent origin, resulting in the acute empyema? 3. Is the infection of long standing and has it involved the mucous membrane lining the sinus? If of dental origin, the tooth which occasions the trouble must be removed, the infection treated with iodin, etc., and the wound permitted to close as early as possible. If the condition is acute and the teeth are apparently sound, an effort should be made to overcome the difficulty through the ostium by using Hartmann's cannula. If the drainage obtained by this method is not sufficient, a counter-opening

with Myles' or Abrahams' trocar should be made in the inferior fossa, and irrigation be performed through the cannula. If necessary an opening may be made with the trocar in the middle meatus also, thus giving still better drainage. A tendency to occlusion by granulation tissue must be overcome by constantly enlarging the opening with some biting forceps (Kerrison's or Myles'). In the majority of instances a cure can be effected by careful and continuous irrigation. If, however, such efforts fail and there is reason to suspect that the mucous membrane lining the cavity is affected, the more radical procedure, described

FIG. 266.—KERRISON'S BONE-CUTTING FORCEPS. (Barnhill and Wales.)

as the Caldwell-Luc operation, in which general anesthesia is advisable, should be performed.

First Step.—1. Pack the cheek and the space between the lip and the lower jaw with gauze to prevent, as far as possible, the escape of blood into the mouth, and also to check the salivary secretions from this area. 2. Make an incision in the gingivolabial fold from the second incisor to about the first molar, through the mucous membrane and periosteum. To insure the subsequent closure of the wound by sutures, it is well to have sufficient flap for this purpose attached to the alveolar process. 3. Elevate the periosteum with a blunt elevator well upward and backward, until ample room is secured for entering the canine fossa with ease. 4. Enter the canine fossa with a gouge, the direction of which should be backward and outward. A dental burr may be likewise employed for this purpose. After entrance is gained, the opening should be rapidly enlarged until it is of sufficient size to admit the little finger. 5. Rapid curetment of all granulation tissue, polypi, or diseased mucous membrane should now be performed. At this point free hemorrhage is likely to occur and can only be controlled by the removal of all granulations or diseased tissue. For

this purpose the curets designed by Coakley are very serviceable, being so made that the many angles of the antrum can be cleaned out. Examination should then be made for necrotic bone, which, if present, should be removed. Frequently septa are found within the antrum, walling off angles of the cavity which harbor septic material. These should be broken down and the granulations cureted away, for if allowed to remain they will act as new foci for suppuration. The antrum should be connected with the nasal chamber by cureting away the nasal wall of the former. The antral wall must be lowered until it is level with the nasal floor. The mucous membrane should now be made into a flap which may have its attachment anteriorly and thus cover the anterior wall of the antrum; or, preferably, it may retain its attachment to the floor of the nose and be made to line the floor of the antrum. This flap of mucous membrane may be anchored with a catgut suture to the periosteum, if any remains, or it may be held in position with gauze packing. This packing should be free from the nasal entrance inward, so that the mucous membrane is held in position during this act. Lastly, suture the gingivolabial incision with catgut, employing a continuous rather than an interrupted suture.

After-treatment.—Liquid alimentation should be given for the first five days and no effort at speaking should be permitted, for both eating and speaking necessitate some movement of the lips and this tends to retard the union of the gingivolabial wound. Remove the gauze in forty-eight hours and replace by packing without irrigation. There may be some pain in the teeth and also some infra-orbital neuralgia due to the disturbance of the dental and infra-orbital nerves, but this will disappear in two or three days. The dressing should be done every other day until the discharge is comparatively small, when a longer interval may be permitted to intervene. The quantity of gauze packing should be lessened daily. If the ethmoidal and sphenoidal sinuses are involved in addition to the antrum, they should be carefully cureted through the antrum.

Mucocele is frequently the result of chronic catarrhal inflammation of the mucous membrane lining the antrum, but it may be due to the occlusion of the mucous ducts in the glandular structure of the mucous membrane. The tumor may be single or multiple and is made up of low-grade epithelial cells, some blood-corpuscles, and a large amount of fluid material containing considerable mucin (Kyle).

Symptoms.—Pressure symptoms are present just as with retained pus, but without the systemic manifestations of pus intoxication.

Treatment.—Curetment is the only trustworthy method of treatment. It may be performed through the canine fossa or through the inferior meatus of the nose.

Foreign Bodies in the Antrum.—These may be classified as animate and inanimate. The inanimate objects are usually dental burrs, cannulas, drainage-tubes, cotton, etc. Under this head may also be classified pieces of broken bone, loose teeth, and pieces of steel or lead from injury.

Treatment.—For the successful removal of foreign bodies from the antrum it is necessary to make a wide opening through either the canine fossa or inferior meatus of the nose. Efforts to float the body within reach of the forceps by filling the cavity with water are made with difficulty. Injections of weak carbolic acid or formalin will kill any animate object, and frequent douching with antiseptic solutions through a moderate-sized opening in the inferior meatus of the nose will relieve all the subsequent symptoms.

Tumors of the Antrum.—Tumors of this cavity occur infrequently. Polypi and osteoma are the benign growths most frequently encountered. Both sarcoma and carcinoma may involve the antrum either primarily or secondarily. (See chapter on the Jaws.)

Ethmoid Sinuses.—Owing to the anatomic relation of the ethmoid cells to the sphenoid sinus behind, the frontal sinus above, and the maxillary sinus laterally, these cavities are peculiarly subject to the inflammatory and purulent conditions existing in any of these locations. The natural drainage of the anterior cells is at about the same location as that of the frontal and maxillary sinuses, so that infective material discharging from either of these two can readily be forced into the ethmoid cells by blowing the nose. The same is true with regard to the opening of the sphenoid sinus and the posterior cells. The thinness of the investing membrane and the intercellular structure adds to their susceptibility to infection, and the frequency of turbinal turgescence occasions in the same degree of frequency occlusion of their natural drainage. The presence of nasal growths or marked deflection of the septum frequently prevents free drainage of these cells and creates a catarrhal inflammation of their lining membrane, which engenders infection. The catarrhal inflammation may exist only so long as the rhinitis which causes it remains; or, if this be due to a growth, until the latter is removed. There is usually headache with the pain referred to the postorbital region, some lacrimation, and a discharge in excess of that of an ordinary rhinitis. The inflammation may subside spontaneously or may become purulent. The latter condition may be acute or chronic.

Purulent Ethmoiditis.—*Etiology.*—Purulent ethmoiditis may occur as a sequence of simple catarrhal inflammation or may be due to a direct extension of the purulent condition in any of the adjacent sinuses. The presence of nasal growths, anatomical displacements, or morbid conditions causing obstruction to proper drainage of the cells, with retention of their natural secretion, will favor infection. Syphilitic, scrofulous, or tuberculous individuals seem particularly susceptible. Traumatism is responsible in some cases and an abscess of the septum may occasionally cause it. Foreign bodies, either animate or inanimate, and phosphoric intoxication are given as remote causes of empyema of these sinuses. There are certain diseases which apparently predispose to ethmoidal suppuration, as erysipelas, influenza, and other infectious diseases.

Symptoms.—Purulent ethmoiditis is most frequently unilateral,

though often bilateral. Some cases are peculiarly free from pain, the only distressing symptom being the persistent and constant discharge of pus from the nasal chambers. Pain, if present, is referred to the postorbital region of the eyeball and, as the disease progresses, extends from the infra-orbital to the frontal region and is of a deep-seated, dull character. The purulent discharge may be fetid and can sometimes be caused to flow by pressure upon the eyeball of the affected side. Inspection of the nasal chamber reveals a thin line of pus issuing from beneath the middle turbinate, and this may accumulate sufficiently to fill the major part of the middle meatus. With the patient in the recumbent position the pus flows into the nasopharynx and later makes its way into the stomach, causing nausea in the morning and leading to gastric trouble. If occlusion prevents the exit of the pus the eyelids become edematous, there may be lacrimation, with the eyeball reddened and bulged; and in some cases fixation of the globe takes place. Diplopia or even blindness may occur. Impairment of the sense of smell is frequent; occasionally it is lost. There is great physical depression and the symptoms of infection are manifested by chill, intermittent temperature, and sweats. In neglected cases an abscess may form at the inner canthus of the orbit, due to the pus breaking through the bony walls of the latter into the soft tissues, which in time may form into a permanent fistula at the inner canthus of the eye. Meningitis not infrequently follows purulent ethmoiditis, due either to the extension of the purulent material along the lymphatics or veins leading to the meninges or to the direct extension of the pus through a necrotic area on the floor of the anterior fossa. As a complication there may follow either a persistent fistula or loss of the eye on the affected side. Death sometimes occurs from meningitis.

Operations.—There are four routes by which the ethmoid sinuses may be reached and drained: (1) Through the nose, by either the natural route or by an artificial opening made possible by the removal of the middle turbinate; (2) the external route through the orbit; (3) through the frontal sinus; (4) through the maxillary sinus.

Intranasal Route.—Remove all the polypi blocking the nasal chamber and remove also the major part of the middle turbinate with a snare. This will give unobstructed vision of the bulla ethmoidalis and the outer walls of the cells. The bulla and outer walls should be broken down with a curet or Grünwald's forceps and all the detritus and contained material thoroughly cureted away. The intercellular partitions should also be broken down, thus converting the space into one large cavity. This is necessary only when the disease is of long duration and the operator is satisfied that mere drainage with irrigation will be insufficient to perfect a cure. Dry gauze packing should be introduced into the cavity with only sufficient pressure to control the hemorrhage. Hydrogen peroxid or irrigation should by no means be employed after this operation. The peroxid tends to force the infective matter through some of the lymph-spaces or along the venous paths to the meninges, thus inviting meningitis. The dressings should

be removed permanently on the next day, so that gravity can drain the cavity. Local anesthesia is all that is necessary in these cases and adrenalin chlorid (1 : 1000) should be applied to control the hemorrhage. The patient should sit up, for in the recumbent position the location of these cells and their adjacent structures is not so easily recognized.

The second method is by the *orbital route*, and is pursued in cases presenting a tumor or a fistula in this locality. The advantages of this route are: (1) It is the most direct way to the ethmoid cells; (2) it enables the operator to have the location of the disease directly under his observation and to see every part that he curets away; (3) better drainage is secured when the ethmoidal space has an opening externally as well as within the nasal chamber; (4) it offers a better opportunity for entering the sphenoid, if this cavity is involved, and likewise affords an opportunity to explore the frontal sinus.

Technic of the External Operation.—Here, as in the other operation, the nasal chamber must be cleared of polypi or other growths, and the anterior two-thirds of the middle turbinate must be snared off. This should be done under cocain anesthesia some days prior to the external operation. For the major operation general anesthesia is necessary and a posterior nasal plug should be introduced. The head should be placed in the Trendelenburg position. A curvilinear incision is made at the beginning of the supra-orbital notch and extending just beneath the supra-orbital ridge to a point midway between the inner canthus of the eye and the junction of the nasal and frontal bone; then curving downward and outward nearly to the infra-orbital foramen. This incision is carried through the skin and periosteum. The latter with its overlying tissues is then elevated from the orbit until the os planum is exposed. If there is a fistulous opening it should be followed with the curet until all necrotic bone is removed and the ethmoidal cells are entirely cureted away, leaving a clean cavity back to the sphenoid. If this cavity is involved it also should be freely opened and cureted. Should there be no fistula to govern the direction taken by the curet, the operator should begin with the gouge upon the os planum and enter the ethmoids by this route. After the anterior and posterior ethmoid cells have been converted into one cavity, and the exploration of the sphenoid and frontal sinuses has satisfied the operator of their non-involvement, the cavity is lightly packed with a sterile or a weak formalin gauze carried out through the nasal chamber (provided there has been no orbital fistula previous to the operation). The external wound is then sutured with interrupted silk sutures. If, however, there has been an orbital fistula or an abscess, it is well to leave a small drainage in the external wound, as well as one in the nose. This external drainage will not complicate matters much nor materially interfere with the proper closing of the wound. A little sterile vaselin added to the external dressing and a Velpeau bandage around the head completes the operation.

After-treatment.—Conservative operators counsel against too free

and reckless operative procedure in this locality. The proximity of the brain and the many channels through which infective material may travel thereto should produce extreme caution in the operator and incite him to a guarded answer as regards prognosis. Many deaths have resulted from operative procedures upon the ethmoids, and owing to their location they should be considered the most dangerous sinuses to be entered and cureted.

Diseases of the Sphenoidal Sinus.—Because of its inaccessible position the surgery of the sphenoidal sinus was neglected for a long time, and was considered to be within the field of the ophthalmologist rather than that of the rhinologist. The anterior wall of the sinus—the one with which the rhinologist is mostly concerned—is extremely thin and presents two areas for surgical consideration. First, a concealed portion directly behind the posterior ethmoidal cells; and second, a nasal area which is visible to the operator and is the proper site for intervention. In the anterior wall is found the ostium and likewise the spheno-ethmoidal recess of Zuckerkandl. The ostium is in the superior part of the anterior sphenoidal wall and, like that of the antrum of Highmore, acts unfavorably to the drainage of pus from the cavity. It is oval in form and measures from 3 to 5 mm. in its greatest vertical axis. The superior wall of the sinus is likewise thin, but is of compact bone and supports the anterior wall of the brain. The other wall is one which concerns the ophthalmologist and is the site of oculo-orbital complications. As in the other sinuses, there may be acute or chronic catarrhal inflammation, which may become infected and produce an empyema. Doubtless a catarrhal state frequently exists in the sphenoid, occasioning considerable nasopharyngitis, headache, and general symptoms of malaise, but clears up without particular attention being directed to it. Empyema, however, is a more serious consideration, and it is doubtful if this ever clears up entirely without surgical interference.

Symptoms.—Pharyngitis is frequently caused by the purulent material discharging over the surface of the pharynx, accompanied by purulent expectoration and disturbance of taste. Nervous manifestations are frequently present, as vertigo, neurasthenia, violent headache referred to the occiput and postorbital region, and neuralgia of the infra-orbital nerve. There is general disturbance of digestion, with vomiting in the morning, diarrhea, loss of weight, etc. Not so infrequently as might be supposed there results a basal meningitis, the cause of which remains obscure until an autopsy is made. Ocular troubles are frequent, as photophobia, amblyopia, loss of accommodation, and involvement of the optic nerve. Inspection of the nasal fossa reveals pus in the superior meatus and there may be mucous polypi present. Posterior rhinoscopy may reveal pus upon the nasopharynx and the anterior wall of the sphenoidal sinus. Tinnitus aurium is present in a few cases and vertigo is frequently noted. If the pus is retained the pain is intensified and is of a throbbing character, simulating abscess-formation. The patient passes sleepless, restless nights,

accompanied with fever, sweats, and chills. The ophthalmoscope shows choked disc, which is an important diagnostic point. Unless the pressure is relieved the contained pus will break through the sinus wall at the point of least resistance, which is usually at the site of the ostium, but occasionally it breaks through the roof, causing fatal suppurative meningitis. The sinus may be reached with a probe or catheter, entering at the ostium, and evidences of pus may be seen upon the point, thus deciding the question of empyema. The best method of probing the sinus is by means of a flexible probe bent at a slight curve and passed into the nasal fossa with the convexity upward. The point follows the roof of the nasal cavity along the cribriform plate, between the middle turbinate and the septum, until it strikes a resistant plane which is the anterior face of the sphenoidal sinus. Here the

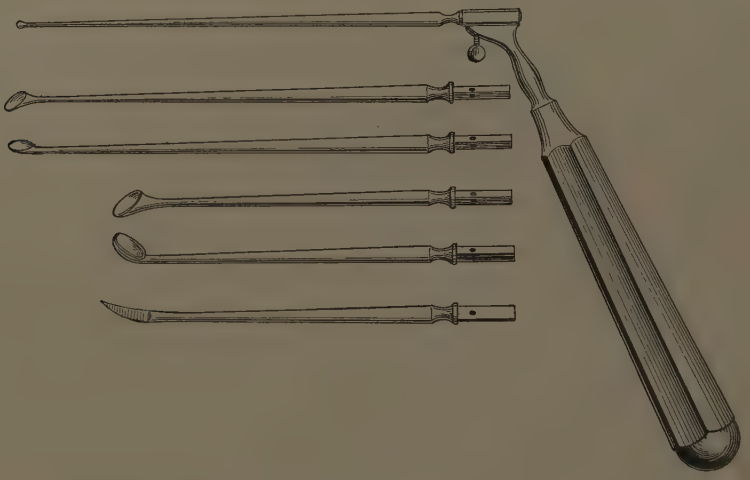


Fig. 267.—Grünwald's Sinus Set.

operator searches for the ostium by moving the probe in various directions, until it enters easily into a cavity, which from its depth leads him to believe he has entered the cranial fossa, but upon closer probing he finds the cavity to average about 1.5 cm. in depth. The probe may be seen in the ostium by means of posterior rhinoscopy. The distance of the anterior sinus wall from the nasal orifice is about $7\frac{1}{2}$ to 8 cm., and the depth of the sinus is about $1\frac{1}{2}$ cm. The route by which the operator may gain entrance to the sphenoidal sinus is determined by the involvement of adjoining sinuses. If the sphenoid alone is involved the route is nasal, as is also the case if the ethmoid cells are also involved; but if the frontal, sphenoid, and ethmoid sinuses are involved the route should be through the frontal sinus; while if the maxillary sinus and sphenoid are involved the route should be through the canine fossa and the antrum of Highmore.

Preliminary Operations.—Remove all polypi from the nasal chamber and also remove the middle turbinate. After this has been

done the operator can frequently see the anterior wall of the sphenoidal sinus. This procedure should be carried out some days before the major operation, as it lessens shock and also permits free drainage of the cavity after operation. The instruments necessary for this operation are a probe, curet, and biting forceps. Bryant's curet is very serviceable in this operation, but the Grünwald sinus set (Fig. 267) will materially aid the operator if there are polypi within the sinus. Grünwald's forceps are likewise the best for biting away the anterior wall of the sinus.

The Technic.—Introduce the probe into the ostium and leave it *in situ*. Pass the curet along the border until its "nose" is against the ostium of the sinus; it is then perfectly safe to curet downward and backward, breaking away the thin anterior wall to the floor of the sinus. If it is desirable to enlarge the opening above or laterally the Grünwald or Kerrison forceps can be introduced and as much of the sinus wall pinched away as is desirable. The cavity itself should be freed of any polypi or broken-down tissue. Should there be necrosis of the posterior wall or roof, care should be exercised in cureting it away, for there is danger of perforating the walls of the sinus. Other methods of entering the sinus have been advocated by different operators.

Fig. 268.—Abscess over Root of Nose, Originating in the Right Frontal Sinus, and Due to the Micrococcus Catarrhalis. (St. Clair Thomson.)

Frontal Sinus.—There are two cavities between the two plates of the frontal bone, separated by a thin, bony septum, each of which constitutes a frontal sinus. These are seldom of equal size and the dividing septum only occasionally marks the median line. Each sinus has an anterior wall, which is the external table of the frontal bone; a posterior wall, which is the inner table of the frontal bone; and an inferior wall or floor, which is the roof of the orbit. The sinus on one side may vary from being mere cancellous tissue to a large cavity occupying the entire space usually occupied by the two sinuses. The sinus communicates with the nose by the infundibulum or nasofrontal canal, which opens high up under the middle turbinate in the middle meatus.

This sinus, like the others, may be the seat of acute or chronic catarrhal inflammation or it may become infected, giving rise to acute or chronic suppuration. In the latter case there may be polypi present.

The catarrhal conditions are usually the outcome of a rhinitis or the sequence of grip. The sinuses may become infected during or following the exanthemata, and also by extension of pus from adjoining sinuses. The symptoms for the catarrhal conditions are frontal headache upon the side affected; vertigo, particularly when stooping; tenderness on pressure, especially in the internal orbital angle and also upon percussion over the frontal region. If there is empyema present there will be, in addition to the symptoms mentioned, a thin stream of pus in the middle meatus, which, if wiped away, will return if the head is bent forward and retained in that position for a few minutes. There are also certain constitutional symptoms that generally accompany this condition. These are foul breath, a bad taste in the mouth, a slight odor to the nasal discharge, some temperature with chilly sensations at times, and a general feeling of lassitude. Transillumination shows a shadow on the affected side. An empyema can continue for years without creating sufficient disturbance to make the patient consent to an operation, but there are symptoms which arise that demand an immediate operation, such as convulsions, coma, high elevation of temperature preceded by chill, the evacuation of the pus into the orbit, or any external evidence that the pus has broken through the bony walls.

Treatment.—In the catarrhal conditions relief may be obtained by shrinking the hyperemic tissues with local applications of adrenalin chlorid solution (1 : 1000), followed by copious irrigation with hot saline solution. An inhalation of steam containing the vapors of alcohol, menthol, ol. pini pumilionis, and milk of magnesia gives most gratifying results. Should the sinus become infected during the catarrhal stage, more efficient drainage may become necessary, and then the anterior tip of the middle turbinate should be removed and any granulation tissue blocking the nasofrontal duct should be cureted away. A bent catheter can be passed into the sinus and the interior be irrigated, although I consider this method of treatment as frequently inefficient and in many instances practically impossible. There have been many instruments devised to render the internal operation efficient and safe. Ingals, of Chicago, has devised a small trephine which fits over a probe previously introduced into the sinus, which serves to guide the trephine along a proper course in its entrance into the cavity. This approaches a safe intranasal method nearer than any other so far submitted. When granulation tissue fills the sinus, or necrotic bone exists in its walls, or polypi have formed from diseased mucous membrane, nothing short of some external operation will overcome the condition. As long ago as 1793, trephining the frontal sinus for empyema was advocated and practised by Callisen, and the numerous operations since that time for the same condition have been only modifications of the original simple trephining. Formerly a temporary resection of the anterior wall of the sinus was made, after which the bone flap was replaced, and in many instances recovery took place without great deformity.

The *Ogston-Luc operation* has for its object the partial removal of the anterior wall of the sinus, enlargement of the nasofrontal canal, and drainage from the sinus into the nose. The objection to this operation is the imperfect drainage given to the ethmoid region, and the limited view afforded of a large sinus which may be filled with numerous septa closing off infective areas. Turner has also called attention to the fact that in the history of 23 fatal cases, the Ogston-Luc operation was performed in 17.

The technic is as follows: General anesthesia is administered. The postnasal space is packed with sterile gauze and the head supported in a moderate Trendelenburg position. The eyebrow is shaved and the field of operation surgically prepared. The eye is covered with antiseptic dressing. A curvilinear incision is made through integument and periosteum, beginning just above the nasofrontal suture and following the curve of the brow to the external orbital angle. The external table of the frontal bone is well uncovered by the use of a periosteal elevator and the wound held apart by retractors. Care is taken not to injure the supra-orbital nerve more than can be helped. To locate the point of entrance pass a vertical line through the middle of the nose and draw a second line perpendicular to this one and tangent to the superior arch of the orbit. At a distance of 1 cm. from the intersection of these two lines upon the horizontal line is the point of election for entering the frontal sinus. Entrance is gained by the use of a small gouge and a mallet. After the outer table is penetrated a grayish membrane is noticed lining the cavity which can be easily depressed with a probe, and if ruptured is followed by the evacuation of pus when empyema is present. The bony opening is made of just sufficient size to permit of free and thorough curetage of the sinus. If the opposite sinus is suspected the bony septum is chiseled away sufficiently to make the diagnosis, and if this cavity is involved a similar operation is performed on that side. The nasofrontal canal is then cureted and enlarged anteriorly until sufficient drainage is assured. A wick of sterile gauze is then pulled through the nasofrontal canal from the sinus into the nose. A catheter devised by Panas facilitates this procedure. After the drainage is in place the external wound is closed with interrupted sutures of silk and dressed with iodoform gauze. The internal dressing is removed in about forty-eight hours and a mere strip of gauze is introduced. No peroxid of hydrogen is used in such a case, but a normal salt solution may be used at each dressing. Some tumefaction of the upper eyelid usually follows and possibly some extravasation into the orbital tissue, but this soon disappears.

Jansen's Operation.—A curvilinear incision is made just above and parallel to the eyebrow, beginning at the external orbital angle and terminating at the middle of the root of the nose. The root of the orbit or floor of the sinus is exposed by removing the tissues and periosteum with the periosteal elevator. The inferior wall of the frontal sinus, representing its floor—which is the roof of the orbit—is then

removed with a gouge and bone forceps. Free access is thus given to the ethmoid cells, which are removed if diseased. The sinus is cureted and the nasofrontal duct is enlarged. Drainage is introduced, leading into the nose, and is also placed at the lower internal angle of the wound. The orbital fat is relied upon to fill the excavated sinus. If the sinus is large and has many bony septa, difficulty is experienced in properly cureting it. The same method of after-treatment is pursued here as in the other cases.

Killian's Operation.—The operation which now recommends itself to most operators and which is being pursued with the most gratifying results is that of Killian.[9] The general preparation of the patient is the same as in any of the operations described. The brow is not

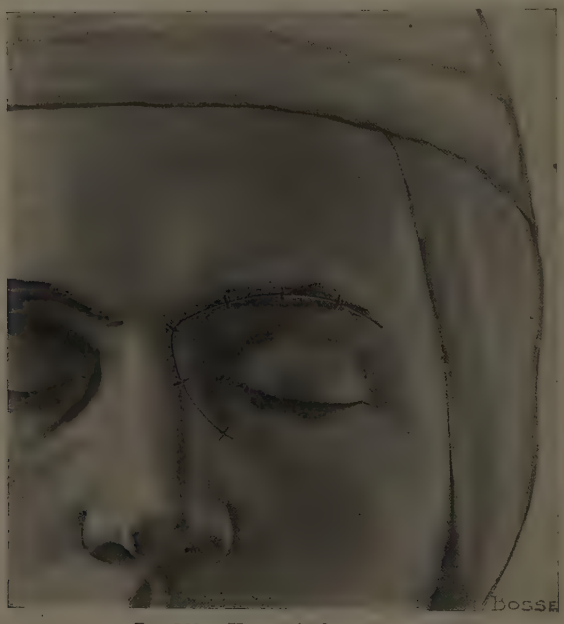


FIG. 269.—KILLIAN'S OPERATION.
First step: Showing line of incision with slight transverse cuts. This initial incision is made through the soft structures to the periosteum.

shaved, but is clipped, and the incision is made through the hair line of the brow from the temporal extremity of the orbit to the root of the nose, dividing the nasal section of the musculus quadratus in the center of the frontal process of the superior maxilla. It ends in an oblique curve outward below the base of the nasal bone. The line of incision (Fig. 269) is marked by slight transverse cutaneous cuts, which enables the operator to properly coapt the flaps of the wound after operation and to lessen the tendency to deformity. After this primary incision is made through the soft parts to the periosteum the soft tissues are lifted away from the periosteum, uncovering the external plate of the frontal bone above, the arch and the roof of the orbit below, and the nasofrontal suture beyond the median line.

Second Step (*Periosteal Incisions*).—(*a*) An incision is made through the periosteum, parallel to the supra-orbital margin and 5 to 6 mm. above, and extending from the temporal end of the eyebrow to the beginning of the root of the nose at its central point. (*b*) A second periosteal incision is made by beginning just median to the attachment of the pulley of the superior oblique muscle and following the line of the cutaneous incision to its extremity (Fig. 270). The periosteum is then elevated from the superior incision over the entire anterior frontal wall; and from the inferior incision is elevated downward, exposing the inner and superior third of the orbit. These elevations leave a strip of periosteum covering the site of the bony arch to be left

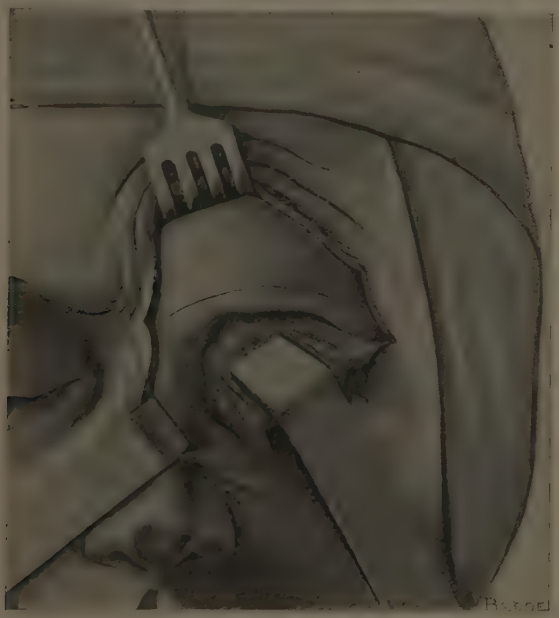


FIG. 270.—KILLIAN'S OPERATION.
Second step: Showing soft tissues retracted, and lines of periosteal incisions.

for the purpose of sustaining the soft tissues after closing the wound. It also gives nourishment to the bone beneath.

Third Step.—Enter the sinus by means of a gouge and mallet just above the piece of bone included between the periosteal incisions and expose the mucous membrane, but be careful not to rupture it.

Fourth Step.—With a probe gently ascertain the extent of the sinus by passing it between the bony wall and the lining mucous membrane.

Fifth Step.—By means of a gouge and mallet excavate a groove through the external table from the first opening into the sinus to the external extremity of the sinus. This groove will then permit of the free use of the chisel in removing the remainder of the bony covering of the sinus without endangering the arch, which it is desirable to retain intact. The entire bony covering of the sinus is thereby removed

and considerable care is taken to uncover properly the angles of the sinus.

Sixth Step.—Thoroughly remove all contents of the sinus and its mucous membrane, also break down all bony septa existing, so that a free inspection of the sinus may be made throughout. Hemorrhage will frequently be profuse until all granulation tissue is removed.

Seventh Step.—Remove the floor of the sinus without injury to the supra-orbital margin which enters into the arch of bone left *in situ.* This procedure may best be accomplished by the operator's standing behind the patient's head and chiseling from above downward. The

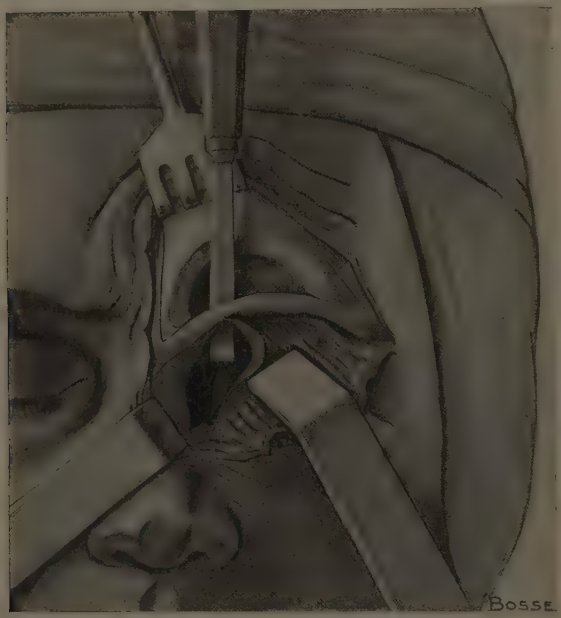


FIG. 271.—KILLIAN'S OPERATION.
Showing position of chisel for removal of floor of sinus. Also extent of bone removed for entrance into ethmoidal cells.

bone is thin and can easily be removed without endangering the contents of the orbit (Fig. 271).

Eighth Step.—Remove the frontal process of the superior maxilla and the remaining part of the floor of the sinus. This may be done without injury to the nasal mucous membrane, which is made into a flap in the following manner: Perforate the membrane by a pointed scalpel at the edge of the nasal bone. Then by means of a probe-pointed scalpel continue the incision upward and backward 0.5 cm. below the cribriform plate; then downward. This flap is tongue-shaped, is turned outward, and used to cover those parts of the wound facing the nasal cavity. This establishes a permanent communication between the frontal sinus and the nose. With care in the removal of the bone overlying this mucous membrane a large flap may be obtained which will serve a good purpose.

Ninth Step.—Remove the ethmoid cells, both anterior and posterior, if diseased; also the middle turbinate. Likewise remove the anterior wall of the sphenoid and curet this cavity if it is involved. Grünwald's forceps are serviceable in performing this operation. In order to reach the posterior ethmoid cells and the sphenoid it is frequently necessary to chisel away a part of the nasal bone on the side involved. This does not complicate the general healing of the wound.

Tenth Step.—Irrigate the wound with salt solution and dust with iodoform. Run a gauze wick from the temporal extremity of the frontal sinus into the nasal chamber through the frontonasal duct and terminate at the nasal vestibule. The incision is then sutured with the expectation of primary union. Care is exercised in the coaptation of the two lips of the wound and the little cuts previously made across the first incision materially aid in this matter.

After-treatment.—Place the patient on the healthy side. Give strict orders that he shall not blow his nose, but must aspirate the secretion flowing from the wound. Dressings must be made daily, but no irrigation must be used. The gauze packing is removed on the second day and the sutures on the fourth or fifth day. Care of the wound internally must be continued over a period of two to six months. This after-treatment is tedious and the granulations constantly springing up must be cut down with strong silver nitrate solution. Even fused nitrate of silver on a probe is necessary in many instances. Deformity frequently results from this operation in the form of a depression superior to the bony arch which is left to support the tissues. This depression may be filled in by the subcutaneous injection of paraffin, correcting the deformity. A soft, mushy condition may be felt in the angle of the orbit for a long while after the operation and a fistula sometimes forms at this point.

Foreign Bodies.—Chronic catarrhal or suppurative inflammation is frequently excited by the presence of some foreign body, as a button or shot, a piece of metal, or a spicule of bone. The wound at the time of the accident may be perfectly aseptic and healing may take place without incident; but in after years the foreign body causes an inflammatory condition which becomes infected, giving rise to an empyema.

Tumors.—Neoplasms of the frontal sinus are less frequently met with than in any of the other sinuses. Cysts, osteomata, and fibromata have been reported, of which cysts are the most frequent. Malignant growths are rare and usually invade the sinus secondarily, their origin being in some other location.

THE NASOPHARYNX AND TONSILS.

Anatomy of the Pharynx.

That portion of the throat between the posterior nares and the cricoid cartilage is termed the pharynx. It is subdivided for convenience into the *nasopharynx*, or upper part, which terminates at the level of the palate; the *oropharynx*, or middle portion, which extends to the vestibule

of the larynx; and the *laryngopharynx*, or the lowest portion, which opens into the esophagus at the lower border of the cricoid cartilage.

The *nasopharynx* has within its limits the entrances to the Eustachian tubes, around each of which is a cartilaginous ring covered with mucous membrane and called the Eustachian promontory. Just posterior to this promontory is a fossa or depression, called the fossa of Rosenmüller. Occupying the highest and most posterior part of the *nasopharynx* is a mass of lymphoid tissue called Luschka's tonsil, or the third tonsil. This mass of tonsillar tissue lies directly against the basilar process of the occipital bone. The posterior nares, or choanæ, open into the *nasopharynx*, and many of the tumors arising from the turbinate bones project into this space. Around the entrances of the Eustachian tubes are many small mucous glands, and the fossa of Rosenmüller is frequently filled with the enlargement or extension of the lymphoid structure, called Luschka's tonsil. This tonsillar mass has no regularity of arrangement, but may be found in parallel ridges separated by deep fissures, or with smooth regular surface, or again in clusters of a grape-like appearance. Just where the pharyngeal tonsil emerges into the *oropharynx* a small orifice appears which leads into a pouch known as the pharyngeal bursa. Recent observers claim that this is not a normal anatomical condition, but the result of an inflammatory process.

The Oropharynx.—In this region are to be described the uvula and soft palate, the *retropharynx*, and the faucial tonsils. The faucial tonsils are two in number, obovate in shape, and symmetrically placed in the faucial ring between the anterior and posterior pillars. Above each tonsil is a triangular space formed by the faucial pillars, called the supratonsillar fossa. The entire sulcus or fossa in which the tonsil is placed is lined by the amygdalo-epiglottic fold, which in turn is enfolded in the superior constrictor muscle of the pharynx. These two structures, together with some fibrous elements lining the fossa, are all that intervene between the tonsil and the sheath of the internal carotid artery. The ascending pharyngeal and the ascending palatine are likewise close at hand and are of considerable surgical importance in operating upon the tonsils. The arterial supply of the tonsil is derived from the facial through the ascending palatine and its tonsillar branches; also the lingual and ascending pharyngeal. There are deep and superficial lymphatics which pass into the upper carotid cervical glands. In addition to the faucial tonsils the oropharynx contains aggregations of lymphoid tissue at the base of the tongue called the lingual tonsil. This tonsil is less prone to disturbances than the faucial tonsil, but it may become hypertrophied and offer mechanical irritation to the epiglottis, and also create a hacking cough that is very annoying to the patient. It also becomes the seat of infection resulting in abscess, which in many instances is reported as abscess of the tongue. At the base of the tongue we may see many varicose veins which are usually the accompaniment of disordered digestion and constipation.

The *laryngopharynx* is the lowest division of the pharynx and is of

particular interest because of the frequency with which foreign bodies lodge in this position. It is also the site of strictures from burns—either from heat or acids. This region embodies both the esophageal and laryngeal entrances.

The *retropharynx* is the entire posterior wall of the pharynx, from Luschka's tonsil to the esophagus. It is protected in front by the pharyngeal aponeurosis, which covers the longus colli and recti capitis antici muscles and loose areolar tissue. The bodies of the cervical vertebræ and the basilar process of the occipital bone form the bony background. The uvula and soft palate close the nasopharynx during deglutition and, with the epiglottis, assist in shutting off the buccal cavity during normal nasal respiration.

Surgical Diseases of the Pharynx.

Traumatic Pharyngitis.—Any inflammatory condition of the pharynx caused by wounds, foreign bodies, inhalation of vapors, dust, or caustic substances may be termed traumatic. The swallowing of acids, alkalies, or boiling solutions, or the inhalation of hot air or steam will create considerable traumatism in the tender tissue of the pharynx.

Syphilis.—Primary syphilis of the pharynx is uncommon, although instances are cited of chancre on one of the tonsils; even one instance of chancre on the lingual surface of the epiglottis is reported by Krishaber, yet the majority of syphilitic manifestations in the pharynx are either secondary or tertiary. The pharynx, however, is the favored spot for mucous patches and for other manifestations of constitutional syphilis.

Symptoms of Secondary Syphilis.—There is little more than an irritation felt in the throat, which may reach the severity of pain. Objectively, erythematous or mucous patches symmetrically arranged and even approaching symmetry in size are present, or there may be an isolated area of erythema which rarely appears above the line of the hard palate. A slight elevation of temperature usually occurs at this time and the patient has a dry, hacking cough, due to pharyngeal irritation. Following the erythema is the mucous patch, which begins as a dusky red elevation and undergoes softening and necrosis. This results in a round patch with well-defined borders projecting just above the surrounding mucous membrane, covered with a grayish, virulent secretion, and this area is surrounded with an areola of inflamed tissue. The mucous patch is usually superficial in its involvement, but terminates frequently in a fibrous scar.

Tertiary Lesions.—These lesions may be inherited or acquired. In the acquired form there may be manifestations seven years after the primary chancre or they may not appear for twenty years after. If hereditary, it usually occurs after the fifteenth year. The gumma is the characteristic lesion, but in some cases there may be a widespread ulceration involving the whole pharynx, which is of a malignant, gangrenous nature, with a tendency to speedy death. The gumma may form anywhere upon the tissues of the pharynx and is smooth and

well defined before ulceration takes place. When the latter occurs (which is the rule) the mucosa is rapidly destroyed, the tonsillar pillars are eroded, and the velum and soft palate may slough away entirely or be perforated in one or more places. When ulceration takes place laterally the deep blood-vessels of the neck are occasionally involved, giving rise to fatal hemorrhages. Necrosis may likewise involve the hard palate, the vertebræ, and even the base of the skull. The odor is characteristic and very foul. Quantities of necrotic tissue mixed with foul, ill-smelling pus are discharged and fragments of dead bone come away in irregular pieces. Large cicatricial areas follow these processes of the tertiary stage and partial or complete occlusion of the nasopharyngeal space results, with loss of function.

Treatment.—The greatest benefit is derived from the internal administration of mercury and potassium iodid. In fact, no benefit from local treatment will result unless constitutional treatment is instituted at the same time. Recently the hypodermic injection of salicylate of mercury has given most marvelous results in tertiary and late secondary syphilis. No operative measures should be begun until the patient has been under constitutional treatment sufficiently long to note its beneficial influence. The two surgical features to be met are the adhesion of the soft palate with the pharyngeal wall and the presence of detached pieces of dead bone. The adhesion of the soft palate to the posterior pharyngeal wall is a puzzling proposition for the surgeon, and the simple separation of these two structures is sure to result in a re-formation of the adhesion. Kollbrunner, Hamilton, and Schadle, at about the same time, designed palatal plates of vulcanite, made from a cast of the nasopharynx, to serve the purpose of preventing the adhesion of palate and pharynx, after separation, by being worn for six months following the operation. Hamilton[10] reports 4 cases treated successfully by this method. Schadle[11] cites 1 case treated by an obturator of special design, which appears to be a mechanical device worthy of trial. No attempt at correcting these defects should ever be instituted until the patient is thoroughly under specific medication, which should be maintained throughout the time that the obturator is worn. Another method of overcoming these palatopharyngeal constrictions and adhesions is that of Elsberg, which is to separate the adhesions with a blunt staphylorrhaphy knife, forcing the finger through the opening into the choanæ, and have the patient maintain the separation by the daily use of a hard-rubber palate retractor.

Tuberculosis.—Primary tuberculosis of the pharynx is extremely rare and comparatively few instances are reported. Chappell[12] reports 1 case where the evidence is unmistakable, and Barstow[13] reports another, where the circumstances point to primary involvement, but there is, in the latter, room for speculation as regards a positive diagnosis. Secondary tuberculosis of the pharyngeal structures is by no means so rare as the primary, yet out of the many hundreds of phthisical patients coming under observation in the large throat clinics, comparatively few have involvement above the epiglottis. The frequency of so-called

tuberculous hypertrophy of the pharyngeal and faucial tonsils has been somewhat reduced by the experimentation of modern investigators, who have shown that the possible errors of former observers were due to the fact that the guinea-pigs inoculated therefrom were probably infected by the tubercle bacilli existing in the crypts or folds of mucous membrane.

Symptoms.—There is pain at the site of the process. At first the sensation is that of a dry, parched, or burning ache; this later becomes a lancinating pain, radiating toward the ear, particularly if the lateral wall of the pharynx is involved. Ingestion of food and liquids increases the pain, which becomes progressively more intense as the disease advances. The voice is thick and assumes a nasal quality, while there may be a dry, hacking cough. The other symptoms are those referable to tuberculosis of the lungs.

Treatment.—Rest and climate are the most potent factors in overcoming this trouble. Nearly every acid has been applied to the tuberculous area with the hope of preventing the progress of the disease. Even cureting the ulcers has been advocated by some, but the present consensus of opinion is that cleanliness, rest, food, and climate are the essential elements for checking the disease.

For the following subjects—Retropharyngeal Abscess, Ulcers, Erysipelas, Glanders, Actinomycosis, Anthrax, Boils, Carbuncle, and Lupus—see Vol. I.

Benign Tumors of the Nasopharynx.

Fibromata.—These are found more frequently than any of the other tumors of the nasopharynx, and differ in no way from the same growth in the nasal chambers. They spring from either the periosteum or connective tissue of the vault of the pharynx and frequently attain great size, necessitating major surgical procedures to remove them. Lincoln and Price-Brown have reported cases in which the tumor has filled the entire nasopharynx and even entered the cranium. These were removed by means of the galvanocautery. Chevalier Jackson[14] reports the removal of a fibroma from the nasopharynx of a boy aged fourteen which weighed 1270 gr. and had produced pressure atrophy upon the superior maxilla to the extent of obliterating the antrum.

Symptoms.—These are postnasal obstruction, cough, headache, pain, hemorrhage, aprosexia, earache, deafness, and other minor symptoms accompanying postnasal obstruction.

The **treatment** is removal. If the growths are small and pedunculated it is comparatively easy to snare them off with a cold-wire or galvanocautery snare. The size of the tumor should decide the method employed for its removal. In the 58 cases collected and reported by Lincoln, 38 necessitated some sort of major operation, such as division of the hard palate or resection of the superior maxillary bone. Of 14 cases operated upon by the galvanocautery, 11 were cured and 3 relapses occurred. About one-third of the fatal cases died of pneumonia; another third, of

the immediate consequences of pneumonia and septicemia; and the remaining third after long-protracted septic conditions. Many external methods have been devised for the removal of these tumors, most of which have been abandoned for the less deforming methods of removing by piecemeal with the cold snare or galvanocautery, the external carotid of one or both sides being first ligated. The ligation of the external carotid reduces hemorrhage if it does not entirely control it; it also reduces shock and creates in the mind of the operator a sense of security which enables him to operate more thoroughly. A tracheotomy at the time of operation is another safeguard and should always be performed if the tumor is of sufficient size to push the velum well forward. Chloroform should be given through the tracheal tube, as it is far less irritating to the mucous membrane of that region than ether. Chassaignac, Ollier, Roux, and Langenbeck have devised methods of external operation which apply more to the removal of large fibromata within the nasal cavities than to those in the nasopharynx. Nélaton's method applies more directly to the removal of fibromata in the nasopharynx. In large non-pedunculated fibromata, which offer no projecting surface to engage the loop of wire, it is well to attempt reduction by the hypodermic injection of some acid. In my own experience monochloracetic acid in saturated solution has proved effective. A case in which several abortive attempts at removal had been made yielded satisfactorily to this method, and two years after beginning the injection there was no evidence of return. A syringe especially devised for this purpose greatly facilitated the procedure.[15]

FIG. 272.—HARMON SMITH'S SYRINGE FOR INJECTING MONOCHLORACETIC ACID INTO NASO-FIBROMATA.

Papilloma.—This class of tumor is rarely, if ever, found in the nasopharynx in an unmixed variety. Harris reports a case which occurred in a woman aged sixty, where the attachment was to the posterior and upper wall of the pharynx.

Cystomata.—Cysts in the nasopharynx are usually the result of some inflammatory condition causing the agglutination of two folds of mucous membrane. Four cases of cyst of the pharyngeal tonsil have been reported.

Myxomata.—True myxomata are rarely found in the nasal cavities, and are probably never found attached in the nasopharynx. If present in the nasopharynx they have their attachment in the nasal cavities or project from within the sphenoid cavity.

Chondromata.—Chondromata are exceedingly rare, and when found in the nasopharynx have their origin in the nares, usually from the cartilaginous septum.

Osteomata.—These tumors are of infrequent occurrence.

Malignant Tumors of the Nasopharynx.

Sarcomata and Lymphosarcomata.—These tumors are by no means rare in the nasopharynx, and spring from the vault of the pharynx, the fossa of Rosenmüller, or from the basilar process of the occipital bone. They may also originate within the sphenoidal sinus and project into the nasopharynx.

Carcinomata.—The type of carcinoma found in this locality is usually an adenocarcinoma. True cancer here would probably be secondary to cancer of the vertebra, base of skull, or lateral pharyngeal walls.

Fig. 273.—Photograph in 1898.
Child, aged six, affected with nasopharyngea adenoids and subject to epilepsy since the age of four. (St. Clair Thomson.)

Adenoids.—When the lymphoid tissue in the nasopharynx becomes hypertrophied it is dignified by the name of "adenoids" or "adenoid vegetations." Adenoids may be found in nearly every race, being more frequent, however, in highly civilized races and in regions of low altitude.

Etiology.—*Age.*—It is agreed by all authors that adenoids develop in early childhood and are most frequently seen between the ages of two and fifteen. Occasional instances are reported in infants and the newborn, while it is not uncommon to see the condition in adults of forty years. Birkett reports an instance of the removal of tonsils and adenoids in a man of forty-five.

Heredity.—Some authors lay great stress upon heredity as a factor in producing adenoids, and it is frequently observed that many children in the same family have adenoids, whose parents and grandparents have high-arched palates, which condition gives substantial evidence that adenoids were present in early life.

Climate.—Sudden and marked changes in the temperature unquestionably predispose to them. Bad ventilation and damp, humid regions are also favorable to their growth.

Symptoms.—The same symptoms are present which occur from nasal obstruction of any character. The voice is "flat" and without resonance, resembling that of a child with a cold. The expression is dull, the mouth remains open, and the patient becomes a "mouth

FIG. 274.—PHOTOGRAPH IN 1904.
Child aged twelve. This is the same child shown in Fig. 273, but six years after the removal of adenoids and the cessation of epilepsy. (St. Clair Thomson.)

breather." The hearing is frequently impaired and the child is unable to fix his attention on any subject, a condition to which Guye has given the name "aprosexia." The chest does not develop, the patient is restless in sleep, and subject to bad dreams and "nightmares." Colds are frequent and severe, and frequently the patient is subject to headaches, neuralgia, and even chorea. Cough, pharyngitis, and laryngitis are also frequent symptoms.

A positive **diagnosis** of the presence of adenoids can be determined in many instances by the use of the small mirror, carefully inserted behind the uvula and depressed so as to bring the structures of the nasopharynx into view. Sometimes with children this maneuver is impossible and digital examination is then unavoidable.

Treatment.—Unquestionably there are adenoids, the result of systemic conditions—as indigestion, constipation, and rheumatism—which can be reduced by the proper correction of these ailments. However, some surgical method is imperative where the condition is at all chronic. European operators and some of their American colleagues elect to remove these growths without an anesthetic. Careful observation on the part of competent observers has resulted in deploring such a method as being unnecessarily cruel and unsatisfactory in the results. The use of cocain is likewise to be condemned, as it appears to predispose to secondary hemorrhage.

Anesthetic.—Until recently chloroform has been largely employed by competent operators. Ethyl chlorid is largely used abroad and in many of the hospitals in this country. Somnoform is another anesthetic which has recently been exploited for use in these short operations, and so far as time is concerned is ideal, maintaining anesthesia sufficiently long for the proper removal of tonsils and adenoids, but some cases of dangerous depression have attended its use and it has been abandoned. The A. C. E. mixture still has its advocates. Nitrous oxid gas alone is too short in its action and acts unfavorably in young children, but in the opinion of many operators the gas followed by ether forms one of the best anesthetics for this purpose.

Position.—The child should never be anesthetized while sitting up, but if the operator prefers this position when operating, no untoward effects result if the child is held in this position after the anesthetic has taken effect.

A mouth-gag is introduced on the left side and held well backward by the anesthetist. If forceps are used, the left forefinger holds the

Fig. 275.—Chappell's Curet.

palate forward while the blades of the forceps are introduced behind the soft palate, closed, with the tip or nose well up against the posterior end of the septum and the handles brought upward to touch the upper incisors. The blades are then opened sufficiently to engage all the hypertrophied lymphoid tissue of the nasopharynx, and with a twisting motion, accompanied with firm pressure upon the handles, the adenoid is pinched away. The forceps devised by Knight or Brandagee are the best adapted to this work. After the forceps operation a curet is

introduced and the nasopharynx is gently cureted until all fragments of adenoids are removed. A long, sweeping motion with the curet held like a pen accomplishes more good and does less harm than more strenuous efforts. Forceps are being less used in this operation, the curet only being resorted to. This appears a more reasonable method and in the hands of an experienced operator is equally efficient. There is probably a greater variety of adenoid curets than of any other throat instrument, but all are based upon the same principle. The Gottstein curet is the one most commonly employed and no adverse criticism can be brought against it. Chappell's curet has about the same shape as Gottstein's, but has serrations along its cutting border that aid materially in engaging adenoid tissue, and when used with a slight twisting motion from side to side is very effective in removing the growth. The operator must be gentle in its use, as it will cut deeply into the underlying tissue if too great pressure is employed. Gradle of Chicago has devised an adenotome which is a modification of Schuetz's instrument, and which in the hands of some operators works remarkably well. The instrument is so curved and shaped as to fit the pharynx of any child above four years old, and the action of the instrument is so rapid that it is claimed that anesthesia is unnecessary, as there is but little pain.

Hemorrhage.—Fatal hemorrhage has taken place in comparatively few cases following this operation. In such instances some predisposing cause has usually existed, and careful inquiry as to the existence of hemophilia should enable us to reduce the mortality. The hemorrhage can frequently be controlled by forcibly injecting, with a syringe, peroxid of hydrogen through the nares, so that it comes in contact with the nasopharynx. Applications of tannic and gallic-acid solution, or even alcohol, are often effective. Should all these measures fail, recourse to the postnasal tampon may be resorted to.

Recurrence.—Unquestionably, these growths recur at times, even when properly removed. This appears to happen more in children in whom there is an apparent tendency to hypertrophy of the lymph structures. Frequently a recurrence takes place when the growth is removed in very young children, but this should not prevent their removal when they produce disturbances in breathing or hearing.

Tonsillitis, Acute Superficial.—Tonsillitis is an acute inflammatory process of a catarrhal nature involving the mucous membrane covering the tonsil, and is confined almost entirely to children and young adults. Exposure to cold or sudden climatic changes may produce this condition, as may also disturbances of digestion, mouth breathing, vitiated air, irritating fumes, etc.

Symptoms.—These are malaise, headache, stiffness in the muscles of the neck and back, chilliness followed by pyrexia, pain on swallowing, and reflex pain in the ear. The tonsil is swollen, deep red in color, and the uvula and soft palate may be edematous. The voice becomes nasal, owing to encroachment upon the nasopharynx by the swollen structures.

Treatment.—Free purgation should be immediately instituted. Local applications of equal parts of guaiacol and albolene are frequently

effective in lessening the intensity of the attack. In the beginning, pellets of ice in the mouth and the Leiter coil or an ice-bag, externally, is of unquestioned value. Tincture of chlorid of iron and glycerin (each 30 drops), added to a wineglass of water, used as a gargle and then swallowed, has been long employed in this condition. If the process is of several days' standing, hot applications externally—as flaxseed poultices and hot gargles—are better than ice. Ammoniated tincture of guaiac (20 drops) to a wineglass of hot milk is a good gargle at this stage.

Follicular Tonsillitis.—In this variety the mucous membrane lining the crypts is involved in addition to that covering the tonsils. Those tonsils with the greatest number of crypts are the most susceptible, and the depth of the crypt likewise bears upon the frequency of involvement. The same etiologic factors obtain here as in the acute superficial type, but the condition is found more frequently in those with tuberculous or strumous diatheses, or where some systemic disturbance has weakened the physiologic resistance of the tonsil. The symptoms are about the same. Pain is more constant, the breath is foul, and there is more gastric disturbance. The crypts become perfect culture-tubes of infection, there being present heat, moisture, and absence of light to promote germination. Through this medium morbific germs gain entrance to the system, and many systemic disturbances can be directly traced to the diseased tonsil as the starting point. Another interesting fact is that one attack of tonsillitis predisposes to a succeeding attack, thus demonstrating a permanent reaction in the resisting power of the tonsil itself. The site of the crypt is marked by a yellowish secretion exuding therefrom, while the rest of the tonsil has a dark red, edematous appearance.

Treatment.—The internal administration of quinin and salol should be immediately instituted, and local application of peroxid and water should be followed by the application of equal parts of guaiacol and sweet almond oil. It is not advisable to curet the crypts, as it is apt to excite rather than diminish inflammation and frequently leads to quinsy.

Parenchymatous Tonsillitis (Quinsy).—In this variety of tonsillitis, the gland substance proper of the tonsil is involved in the inflammatory process, in addition to the mucous membrane covering the tonsil and that lining the crypts. The symptoms are but exaggerated forms of those found in the other two varieties of tonsillitis, and the results are nearly the same, except that peritonsillar abscess and quinsy more frequently follow the parenchymatous tonsillitis. The treatment is the same. The phlegmons seem to follow more quickly the last-mentioned type, and often the opposite tonsil will develop a quinsy or a peritonsillar abscess.

Few disturbances in the throat occasion more pain than quinsy. There is usually a chill followed by high fever and sweats, with pain of intense nature on swallowing or on opening the jaw. The voice is thick and muffled and there is a peculiar intonation which is almost charac-

teristic of the condition. The patient will frequently go without food rather than undergo the pain of swallowing. The uvula is edematous and the soft palate on the side of the involvement is projected forward and is tense and red in appearance. The saliva is markedly increased and drules from the corners of the mouth. The tonsil itself is swollen and edematous.

Treatment.—Flaxseed poultices externally and hot saline gargles are the most acceptable to the patient. Scarification gives some relief, and an early endeavor to reach the pus frequently evacuates sufficient serum to relieve pain, even if there is failure to reach the pus. It is by no means an assured fact that the operator is going to strike the pus cavity at the first incision. An endeavor should be made to locate the point of greatest tension by both sight and touch, as at this point the pus will most probably be found. A sharp-pointed bistoury should be used for the incision, with only ½ inch of the tip projecting, the other half of the blade being protected with a band of adhesive plaster. After the incision is made through the mucous membrane and the pus is located, a pair of nasal scissors can be introduced closed and then withdrawn with the blades separated, in this way enlarging the opening. Should pus not be reached at the primary incision, some blunt-pointed instrument should be used to puncture in various directions in order to locate the pocket, as it endangers neighboring blood-vessels to probe promiscuously with a sharp-pointed bistoury.

Hypertrophic Tonsillitis.—For clinical purposes this class of tonsils is divided into soft and hard, the first being the most frequent and found earlier in life; while the latter results from repeated attacks

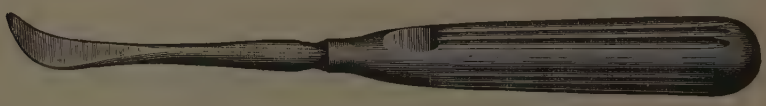


Fig. 276.—Yankauer's Tonsil Separator.

of tonsillitis, and while frequently found in children is more often seen in young adult life. Often the soft form is accompanied with increase in all the lymphoid structures of the "ring," and the other mucous follicles in all these structures seem involved. There is more reason to believe that the soft tonsil will atrophy than the hard one, for in the hard variety there is a proliferation of connective tissue which tends to prevent the atrophic process. Knight has given a good classification of hypertrophied tonsils from a clinical standpoint: (1) Those in which the size interferes with deglutition or respiration; (2) flat tonsils, not specially enlarged, but prone to recurrent attacks of inflammation and frequently the foci of suppuration, the formation of pus not necessarily taking place in the body of the tonsil, but sometimes in the adjacent tissue; (3) a class of tonsils in which there may be little or no hypertrophy or encroachment upon the pharyngeal space, because of adhesion of the pillars to the surface of the organ as a result of repeated attacks of rheumatism. These adhesions should always be liberated before

an effort is made to remove the tonsil, the best instrument for this purpose being one recently devised by Yankauer (Fig. 276), which possesses sufficient solidity to withstand the necessary effort to liberate the folds and is at the same time properly curved to liberate the lower part of the tonsil, which is the part most frequently left attached. The size alone of the tonsil should not govern one in a decision as to removal, for often the small tonsil with open crypts will occasion more harm than a large one. A so-called encapsulated or buried tonsil is likewise a more dangerous element than an ordinary large tonsil. The ability to discriminate comes with experience and observation, and merely the presence of hypertrophied tonsils without interference with respiration or deglutition or the manifestation of other disturbances constitutes no good surgical indication for removal.

Symptoms.—The symptoms of hypertrophied tonsils are numerous and varied, comprising frequent desire to swallow, pharyngeal irritation, reflex nausea, dysphagia, with frequent regurgitation of foods and fluids through the nose. Earache and occasionally tinnitus may be present, but these are exceptional.

Treatment.—There are some surgeons who still adhere to the principle of treatment as the best measure to be adopted in regard to hypertrophied tonsils, claiming that in due time nature reduces them, and that they stand as guardians at the gateway of infection and unquestionably diminish the lung complications that would otherwise ensue. In favor of this argument, it is admitted that the tonsils do intercept numerous bacteria that would otherwise gain entrance to the lungs. It is also admitted that by fatty degeneration of the tonsillar stroma the tonsil itself diminishes with age, so that in the course of time it becomes harmless as a starting point of disease. These methods of degeneration have been clearly demonstrated in recent articles by Dr. Jonathan Wright. It is the opinion of most specialists that when the tonsils are sufficiently enlarged to interfere with respiration, phonation, or deglutition, or with the functions of the ear, they should be removed. Ignipuncture may be tolerated in certain isolated cases, where there is a tendency to bleed freely from operations, or where the patient or parents absolutely refuse operation, but under ordinary circumstances removal is the best treatment to be pursued.

Removal in Children.—*Preparation.*—It is best to perform the operation in the early morning, soon after the child wakens. A light supper the night before, a mild cathartic, and fasting are all that is essential. The temperature should be taken before the operation, and if this is 100 or more the child should be held under observation for a day or so, as it might be the prodromal temperature of some exanthem.

The operating-table should be about 3 to 4 feet high and narrow, if possible. If the operator is doing many operations, the Chappell operating-table offers one of the most valuable aids to his work, as it is the right height and breadth and is portable. It is well to anesthetize the child in its sleeping-room and bring it into the operating room later, which room should be as light as possible. Some operators

prefer the child held upright; others, with the head down, but in any case the feet should be placed toward the light. If the operator is going

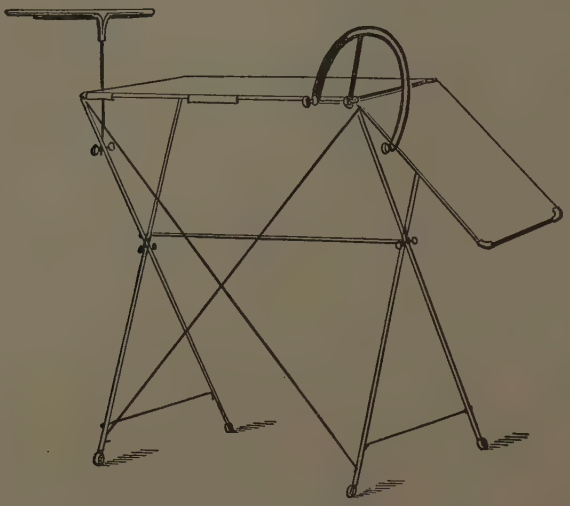


FIG. 277.—CHAPPELL'S OPERATING TABLE.

to use the Mathieu tonsillotome, it is advisable to have the patient held upright, for otherwise it is nearly impossible to get a good view of the

FIG. 278.—CHAPPELL'S OPERATING TABLE.

operative field. With the Mackenzie tonsillotome, the patient's head may lie in the prone position, and when the adenoids are removed be

placed in the Trendelenburg position, which position the Chappell table favors. The tonsillar scissors devised by Roberts and others are better

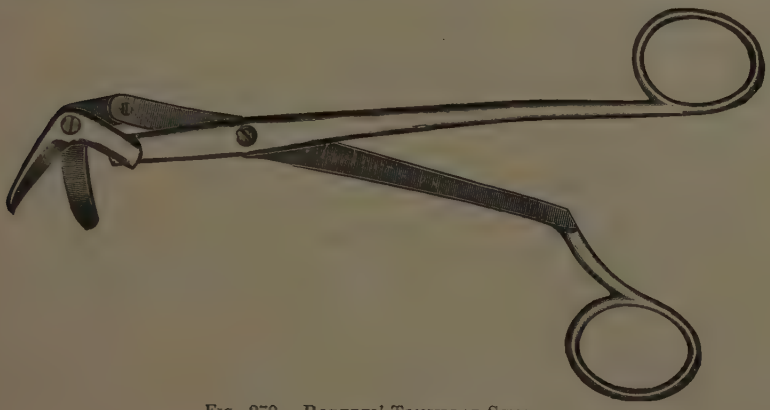


Fig. 279.—Roberts' Tonsillar Scissors.

adapted to the removal of tonsils in adults than in children. The same may be said of the cold snare and the thermocautery snare. With

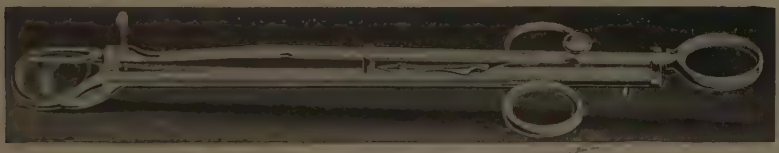


Fig. 280.—Mathieu's Tonsillotome. (Fowler.)

children but two tonsillotomes are to be considered—viz., Mathieu's and Mackenzie's. Both are good, and it is entirely a matter of choice as to

Fig. 281.—Mackenzie's Tonsillotome.

which should be used. In the recumbent position the Mackenzie tonsillotome will probably occasion less traumatism.

After-treatment.—In children little is required. A little cracked ice, ice-cream, and cold milk should be all the nourishment permitted the first day. If there is persistent hemorrhage, peroxid of hydrogen gargled or applied locally, equal parts of tannic and gallic acid in a thick solution applied locally, or the direct application of compound alum powder will usually suffice to check it. Should these measures fail, an attempt should be made to run a ligature around the bleeding point, but the procedure is extremely difficult. As another means, one should apply the Mikulicz-Stoerk tonsillar hemostat (Fig. 282). I have made an addition to this hemostat which is of practical importance when the necessity arises for its application.[16] Care must be exercised not to close the blades too tightly, as slough from pressure is liable to result. Should the patient bleed sufficiently to show air hunger or other serious symptoms, ligation of the external carotid (never the common carotid), transfusion, and similar surgical methods should be employed.

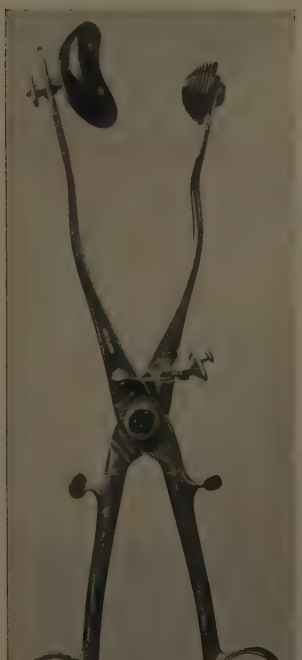


Fig. 282.—Mikulicz-Stoerk Tonsil Hemostat.

Removal in Adults.—In the adult the tonsils may be removed under cocain by tonsil forceps, ignipuncture, galvanocautery snare, and the cold-wire snare. Moseley's tonsil snare is sufficiently strong to perform this operation (Fig. 283).

Postoperative Hemorrhage.—Cautery of any kind is not feasible. Ligation *in loco* is difficult, but the application of the Mikulicz-Stoerk hemostat is both efficient and

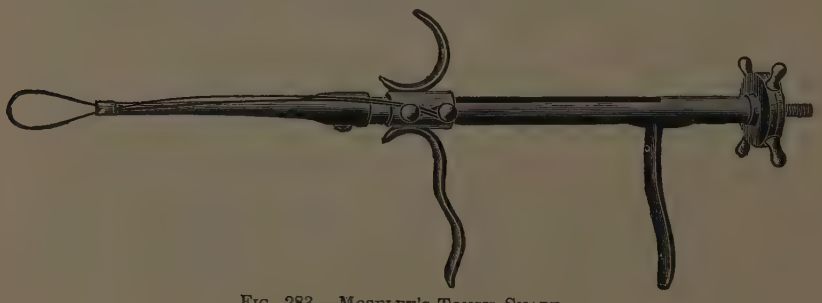


Fig. 283.—Moseley's Tonsil Snare.

comparatively easy. An additional pad of gauze should be used externally to obviate pressure difficulties, and a small piece of gauze soaked in some styptic should be fastened on the hard-rubber pad. If

applied gently and with only sufficient pressure to control the hemorrhage and left on for eight to twelve hours, dangerous hemorrhage may be effectually stopped. Styptics should always be tried first, and recently gelatin has proved a very good agent in the control of tonsillar hemorrhage.[17] Any serious hemorrhage from the tonsil not controlled by the above means is readily controlled, as already mentioned, by ligation of the external (not the common) carotid artery.

The removal of tonsils in young adults does not affect the voice, except that it increases the register in the singing voice and therefore benefits it. After a singer reaches forty there should be some hesitancy in giving an opinion in regard to the effect of the operation on the voice, as in many instances the quality is somewhat changed.

Lymphomata.—This condition is more interesting from a histologic standpoint than from any practical surgical considerations.

Fibromata.—These tumors are generally small and superficial, and associated with some inflammatory changes of a chronic character.

Papillomata.—Papillomata are infrequent, and in the majority of instances spring from the plica tonsillaris, or soft palate, rather than from the tonsil itself. Jonathan Wright [18] has concluded that the majority of so-called papilloma of the tonsil proper is merely a degenerative process on the part of the tonsil from advancing age, and to this process he gives the name "autoclasis."

Angioma.—A few of these tumors have been reported, but as a primary growth of the tonsil it is extremely rare.

Gumma.—This condition is rare, and the clinical symptoms may so resemble sarcoma or carcinoma that serious error may happen in way of treatment.

Tonsoliths.—Very infrequently calcareous concretions, and even bone, have been found in the tonsil; but their size is not sufficient to make them worthy of much surgical consideration.

Sarcoma.—Sarcoma of the tonsil occurs with some frequency. Two varieties are generally met with—small round-cell or lymphosarcoma, which is of a very malignant character; and spindle-cell sarcoma, which is less malignant. The small round-cell variety spreads almost immediately through the lymphatics to neighboring glands, and may be disseminated throughout the body by means of the lymphatics. The spindle-cell sarcoma not infrequently becomes encapsulated and can be "shelled" out of its folds with little existing evidence of involvement of neighboring structures. Such an instance is cited by Newman,[19] in which a spindle-cell sarcoma of the left tonsil was encapsulated and the sarcomatous mass was removed with a Volkmann's spoon, the capsule being separated from its neighboring tissues. The lymphatics were not involved and no recurrence took place for four or five years. The disease then reappeared in the opposite tonsil, with rapid involvement of lymphatic glands, palate, and pharynx. Death resulted three months after this second involvement. While sarcoma involving other structures of the body is a disease of early life, in the tonsil it may be noted that it is distinctly a disease of adults. The majority of cases occur in

males. In the cases referred to by Bosworth, 28 occurred in males, 9 in females, and in 8 the sex was not given.

Pathology.—As a rule the spindle-cell growths are dense in character, even to the point of simulating a fibrosarcoma; they are firm in consistency and are less malignant than any other form. The round-cell variety have little stroma, are highly vascular, and ordinarily are soft and succulent. Their growth in the tonsil is very rapid.

Symptoms.—Discomfort in the act of deglutition is the first symptom noticed, changing later into decided pain. The mechanical interference with the functions of swallowing and speech is early experienced. Hemorrhage is by no means always present, though it usually occurs after ulceration has taken place. Glandular enlargement is always present in the small, round-cell variety, and usually at an early date; while in the spindle-cell sarcoma glandular enlargement may be deferred until late. Ulceration of the surface occurs early in the round-cell variety, giving rise to a disagreeable fetid discharge and markedly increased salivation.

Diagnosis.—In its incipiency sarcoma is to be differentiated from quinsy, syphilis, and epithelioma. In distinguishing it from quinsy the element of time will decide the question. To diagnose sarcoma from syphilis is by no means easy, for at certain stages of the progress in each there is much similarity, and skilled diagnosticians have been led into error. When in doubt, it is well to give the patient a thorough antisyphilitic treatment. It is also frequently difficult to diagnose sarcoma from epithelioma. Epithelioma is warty, irregular in outline, with no demarcation, and the excrescences are pallid. Ulceration is more rapid in epithelioma and cachexia occurs earlier. The lymph-glands are also involved early. The tendency of epithelioma is to involve the tongue and soft palate. The microscope is frequently the only way of determining the nature of the growth.

Prognosis.—Death results in from three to fifteen months if untreated. If operation is performed some hope of prolonged life may be offered the patient.

Epithelioma.—This is always primary, although the tonsil may be attacked by invasion of the disease from either the tongue or the soft palate. The lymphatic glands show earlier involvement in epithelioma than in sarcoma, and ulceration of the surface occurs earlier in the disease. As a rule, cancer of the tonsils is a disease of advanced life, as elsewhere in the body. Lennox Browne's report shows that the relative proportion of epithelioma of the tonsils in males is 60 per cent.; in females, 40 per cent.

Symptoms.—The first indications of something abnormal is the sense of a foreign body in or behind the tonsil. This is soon followed by a pricking and later by pain on swallowing. Respiration is interfered with only by the encroachment of the tumor upon the pharynx or its extension into the larynx. The tendency of sarcoma is to grow backward and outward, forming a large indurated mass beneath the skin of the neck; while the tendency of cancer is to grow forward upon

the tongue or extend downward into the tissues of the larynx. Ulceration of the surface occurs early, and the exudation with the increased salivation produces a fetid discharge which is acrid and irritating, and produces more or less cough. Pain in the ear is a very frequent and early symptom, due largely to encroachment of the mass upon the Eustachian tube. Cachexia is an early manifestation.

Objective Symptoms.—There is increase in the size of the tonsil and it assumes a more lobulated shape. The color is less intensely red than in ordinary inflammatory or infective involvement. The tissue of the tonsil is bleached, and upon the tonsillar folds are numerous small blood-vessels that form a corona to the tonsil itself, while the tissues immediately adjacent are infiltrated. Upon palpation there is a characteristic density.

Diagnosis.—Syphilis, sarcoma, and tuberculosis are all that it is necessary to exclude. The microscope finally confirms the diagnosis.

Prognosis.—The hope of temporary relief is all that a surgeon is justified in holding out to the patient from an operation. If left alone, that is, without operative interference, the patient usually lives from two to eighteen months. If operated upon, the time may be extended five or six months before recurrence. There are also cases reported of complete eradication.

Treatment.—There are two methods for the care of malignant involvement of the tonsils: (1) Palliative; (2) surgical.

Palliative.—Relief of symptoms, as acrid salivation, pain, dyspnea, dysphagia, and hemorrhage, is all that can be hoped for by palliative measures. The excessive flow of saliva and septic secretions produces local irritation, likewise, if swallowed, considerable irritation in the stomach. If the secretions are absorbed the progress is hastened. Antiseptic gargles should, therefore, be frequently used.

Pain.—It is well to use local remedies first and rely upon morphin only for the later stages. Equal parts of chloral, camphor, and thymol rubbed on the neck externally will allay the pain in the early stages; also sprays of cocain or insufflations of powdered orthoform upon the tumor will relieve the pain temporarily.

Dyspnea.—This frequently becomes so aggravated that nothing short of a tracheotomy will avail.

Dysphagia.—This may be avoided by feeding the patient through a tube passed into the esophagus or, as is sometimes necessary, through the nose.

Hemorrhage.—Tannic and gallic acids, equal parts in a solution; alumnol; peroxid of hydrogen; and many of the well-known hemostatic remedies may be used, but it is frequently necessary to resort to ligating the base of the tumor or to cauterization; or even, as a last resort, to tying the external carotid. By saving the patient much subsequent pain, death by hemorrhage is greatly to be desired.

Operation.—Operation upon the tumor may be by the mouth or the external route. Palliative removal of the tumor through the mouth may be accomplished with a tonsillotome supplemented by the curet,

the electric or thermocautery, or by electrolysis. Radical removal, with removal of all the glands, must be done by external operation, with or without a primary tracheotomy. (See chapter on Surgery of the Neck.) Newman[20] has entered at length into the discussion of these methods.

WOUNDS AND INJURIES OF THE NASOPHARYNX AND THE TONSILS.

The majority of injuries in these locations is due to some accident following a fall with a pipe, pencil, or pin in the mouth. Bosworth reports a case of a girl falling with a hatpin in her mouth, the point of which was driven through the soft palate and into the cervical vertebra, necessitating considerable force to extract it. Pipe-stems occasionally penetrate the pharynx and tonsil as the result of some accident. These conditions are rarely met with, however, and during the last eight years I have not seen a single instance of injury to the tonsil that was not the result of trauma during some operative procedure. The surgical aid required in these cases must be determined by the existing condition and by the judgment of the operator. No definite directions can be given that would apply to such cases. All that is necessary is to use ordinary surgical technic.

FOREIGN BODIES IN NASOPHARYNX.

Bones, buttons, coins, and nearly every conceivable object of small size have been known to get into the nasopharynx, either by the act of coughing, sneezing, laughing, or swallowing while the object is in the mouth. Ordinarily little disturbance follows, and the body can be removed without cocain, either with a pair of curved forceps or with the index-finger. Care should be exercised not to permit the object to enter the larynx.

SKIAGRAPHY IN DIAGNOSING DISEASES OF THE NASAL ACCESSORY SINUSES.

Coakley[21] has deduced the following conclusions from the application of skiagraphy in 200 sinus cases, and has classified them according to the sinus involved:

1. The frontal sinus:
   - (*a*) Certainty of demonstrating the presence or absence of a sinus before operation.
   - (*b*) Accurate determination of the size of the sinus.
   - (*c*) Situation of septum between the sinuses.
   - (*d*) Location of partial septa.
   - (*e*) Probable presence of an orbital recess.
   - (*f*) Disease may be determined by an excellent negative.

By this is meant that if the sinus is involved there will be a cloudiness over the area corresponding to the part diseased. In the negative this area is of a milky color, while the uninvolved sinus will appear dark.

When, however, the photograph is made from the negative plate the opposite will occur, so that the involved side appears dark and the healthy air-spaces white.

(*g*) From information obtained from what has been stated, determining in advance the best operative method.

2. Ethmoid cells:
   (*a*) Easy demonstration of the width of the ethmoid-cell area, that is, the space between the nose and the orbit.
   (*b*) The relation of the ethmoid cells to the frontal sinus.
3. Maxillary sinus:
   (*a*) It is unnecessary to apply the *x*-ray for diagnosis of empyema alone, and is only feasible to determine the presence of a foreign body.
4. Sphenoidal sinus:
   (*a*) Determination of the size of the sinus.
   (*b*) Inadvisability of relying upon the *x*-ray as a positive diagnostic agent.

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CHAPTER XL.

SURGERY OF THE LARYNX AND TRACHEA.

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ANATOMIC CONSIDERATIONS.

The larynx, or upper expanded portion of the air-passage, is an irregular conic chamber situated in the median line of the neck opposite the fourth, fifth, and sixth cervical vertebræ. Its framework is made up of several cartilages, the thyroid, the cricoid, and the two arytenoids being the most important. These are held together by the dense cricothyroid membrane and numerous muscles, which also serve to bring about certain changes in the position and shape of the organ during deglutition, respiration, and phonation.

The anterior and upper portion of the larynx is attached to the hyoid bone by the thyrohyoid membrane and the two thyrohyoid muscles. Behind the thyrohyoid membrane at the superior aperture of the larynx is situated the epiglottis, a flat, leaf-shaped cartilaginous body, which is attached to the upper posterior surface of the thyroid cartilage and to the hyoid bone by fibrous ligaments. During the act of swallowing the epiglottis is forced downward and prevents the entrance of food or fluid into the larynx.

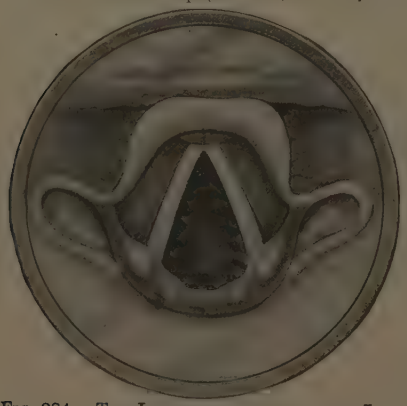

Fig. 284.—The Larynx as seen in the Laryngoscopic Mirror. (Fowler.)
The illustration shows the parts larger than normal in order to bring out the details.

The interior of the larynx is lined by a mucous membrane which is continuous above with that lining the pharynx and below with that lining the trachea and bronchi.

The cavity of the larynx is divided into two portions, an upper and lower compartment, by the true vocal cords, two dense bands of elastic fibrous tissue extending from the thyroid cartilage in front to the arytenoids behind and covered by a firmly attached mucous membrane.

Above the true cords are two other folds of mucous membrane—the false cords—and between the true and false cords on either side is an oblong pouch or sac, the laryngeal ventricle.

The superior aperture of the larynx (Fig. 284), which connects its cavity with that of the pharynx, is a triangular opening bounded in front by the epiglottis, on either side by the aryteno-epiglottidean folds, and behind by the interarytenoid membrane. The mucous membrane over the aryteno-epiglottidean folds and false cords and that lining the ventricles is thick and contains an abundant submucous cellular layer; that covering the true cords is thin and intimately adherent to the fibrous bands.

The sensory nerve-supply of the mucous membrane of the larynx is from the internal branch of the superior laryngeal nerve, which pierces the thyrohyoid membrane with a branch of the superior thyroid artery.

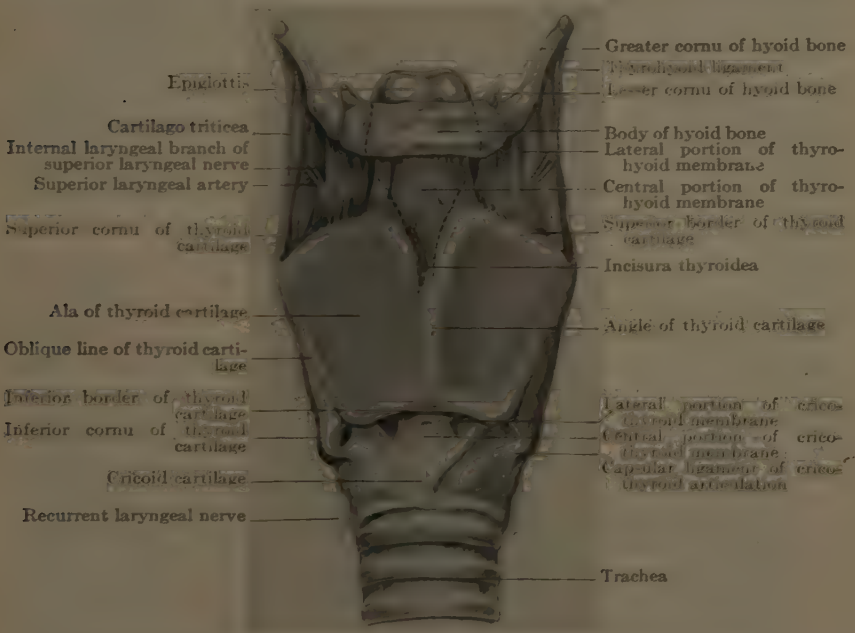
Greater cornu of hyoid bone
Thyrohyoid ligament
Lesser cornu of hyoid bone
Epiglottis
Cartilago triticea
Internal laryngeal branch of superior laryngeal nerve
Superior laryngeal artery
Body of hyoid bone
Lateral portion of thyrohyoid membrane
Central portion of thyrohyoid membrane
Superior cornu of thyroid cartilage
Superior border of thyroid cartilage
Incisura thyroidea
Ala of thyroid cartilage
Angle of thyroid cartilage
Oblique line of thyroid cartilage
Inferior border of thyroid cartilage
Lateral portion of cricothyroid membrane
Inferior cornu of thyroid cartilage
Central portion of cricothyroid membrane
Capsular ligament of cricothyroid articulation
Cricoid cartilage
Recurrent laryngeal nerve
Trachea

FIG. 285.—ANTERIOR VIEW OF LARYNX, INCLUDING CRICOTHYROID MEMBRANE.
(From Deaver's "Surgical Anatomy.")

This nerve also supplies the arytenoideus muscle and through its external branch the cricothyroid muscle, the other muscles being supplied by the recurrent laryngeal nerve. The mucous membrane lining that portion of the larynx above the true cords is exceedingly sensitive, the slightest contact of a foreign body causing violent cough and spasmodic closure. A severe grade of shock almost invariably follows rough handling or trauma in this region, even under general anesthesia.[1]

The lymphatics of the mucous membrane of the larynx are most abundant in the thick, loose membrane of the ventricles, false cords, and aryteno-epiglottidean folds, and are exceedingly sparse in that portion covering the true cords. The lymph-channels from the vocal cords and superior compartment pass outward through the thyrohyoid

membrane and enter the nodes situated beneath the digastric muscles and those situated along the internal jugular vein; those from the inferior compartment pass outward through the cricothyroid membrane, anteriorly and posteriorly, into the pretracheal node and those following the recurrent laryngeal nerve.[2] Fig. 303 illustrates the course of the principal arterial and lymphatic trunks.

The *trachea* is a cartilaginous membranous tube about 12 cm. in length, extending from the lower portion of the larynx to a point opposite the fourth dorsal vertebra in the thorax, where it bifurcates, forming the right and left bronchi. The cartilaginous portion consists of a series of eighteen or twenty incomplete rings; these are bound together by a dense fibrous membrane, which serves to complete the lumen of the tube behind, where the rings are defective. It is lined throughout by mucous membrane, is moderately elastic, and can be lengthened and shortened by movements of the head or neck. The orifice of the right bronchus is larger and more directly in the axis of the trachea than that of the left.

METHODS OF EXAMINATION OF THE LARYNX AND TRACHEA

Prior to the introduction of the laryngoscope (Fig. 286) in 1858, our knowledge of the various pathologic lesions of the larynx and trachea was derived mainly from autopsy findings, and our methods of arriving at a correct diagnosis during life were based upon an interpretation of certain symptoms, as cough, hoarseness, aphonia, dyspnea, pain, etc., together with the results of ocular examination of the mouth and pharynx, and inspection and palpation of the surface of the neck.

Fig. 286.—Laryngoscopic Mirror. (Fowler.)

The value of the laryngoscope, first suggested by Garcia and later demonstrated by Türck and Czermak,[3] was at once recognized by the profession, and its general use rapidly revolutionized our ideas regarding the diagnosis and treatment of laryngeal disorders. The technic of laryngoscopy is comparatively simple and easily acquired. By its employment one can readily ascertain any departure from the normal in the appearance of the tissues of the larynx as far as the true vocal cords, and to a limited extent beyond the glottis even as far as the bifurcation of the trachea.

One must always bear in mind, however, in the presence of grave surgical lesions, that the picture seen in the laryngeal mirror is often incomplete, as the extent of the disease below the cords is often obscured.

The necessity of other and more satisfactory methods of examining

the larynx and trachea was soon appreciated, and led Kirstein, in 1894, to employ a straight tube (Fig. 287) introduced into the larynx through the mouth. Through this tube, by means of a strong electric frontal light (Fig. 288), he was able to see by direct inspection not only the

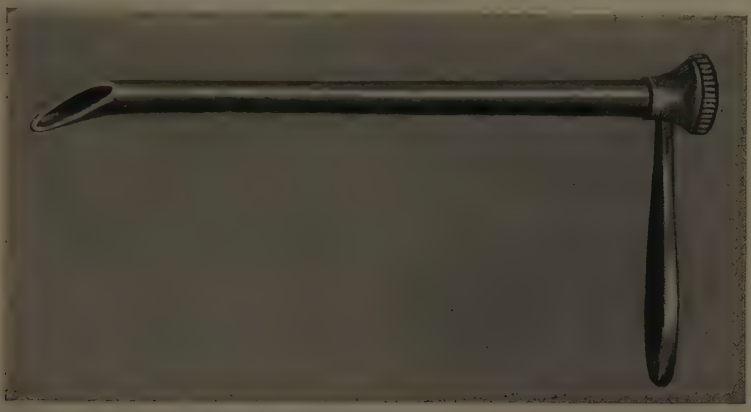

FIG. 287.—GUISEZ'S TUBE SPATULA.

upper part of the larynx but also the tissues of the subglottic region and trachea.[4]

This method has been found particularly serviceable in infants and young children, in whom the use of the laryngeal mirror is often attended with insurmountable difficulties.

FIG. 288.—KIRSTEIN'S LAMP.

With a view to inspecting the trachea and bronchi, Killian, in 1897, made use of longer tubes introduced through the mouth or through a previously made tracheotomy wound. The former method he describes

as *upper direct tracheoscopy* and *bronchoscopy*, the latter *lower direct tracheoscopy* and *bronchoscopy*.[5]

Killian employs numerous tubes, varying from 10 to 35 cm. in length and from 5 to 14 mm. in diameter. These are constructed of metal, nickel-plated and highly polished on the inside (Fig. 289). General anesthesia is required in children; in adults a 20 per cent. solution of cocain liberally applied to the tissues will generally enable the examiner to use the tubes in the majority of instances.

When local anesthesia is employed, Killian prefers to examine the patient in the sitting position (Fig. 290). The patient, sitting upon a stool, extends the head backward as far as possible, the tongue is then drawn forward, and the tube introduced to the region of the epiglottis. By means of the Kirstein head-lamp the end of the tube is next directed over the epiglottis to the region of the aryteno-epiglottidean folds. The examiner then observes carefully the movements of the vocal cords,

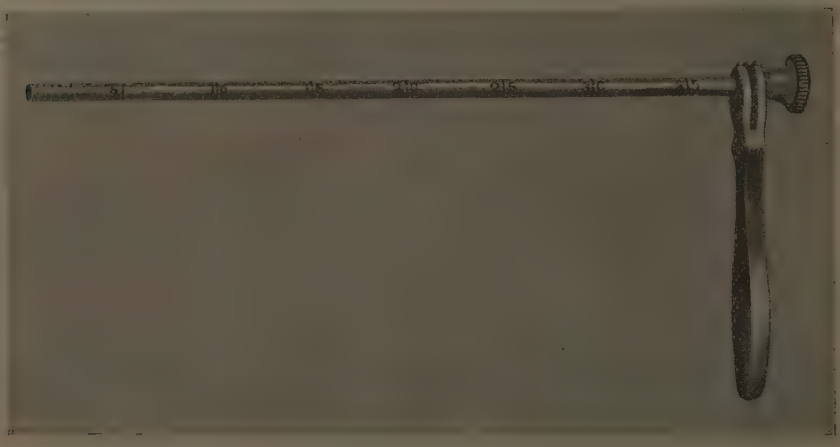

FIG. 289.—KILLIAN'S BRONCHOSCOPE.

and when widely open during inspiration passes the tube through the chink of the glottis into the trachea, and by gentle manipulation of the head and neck the right and left bronchus may be entered and the tube even carried downward to the second or third division of the bronchial tree.

While the above-described procedure may be carried out by those possessed of large experience and great skill, the use of the second method, or lower tracheoscopy and bronchoscopy, is far simpler. Both methods are undoubtedly facilitated by the use of general anesthesia. When general anesthesia is employed the patient should be placed in the dorsal position (Fig. 291) on a table with the head hanging backward over the edge supported by the hands of an assistant (Rose's position).

The tongue is drawn forward and the tube introduced under guidance of the eye of the examiner as described above when in the sitting position. When lower tracheoscopy or bronchoscopy is employed the shorter tubes are used, introduced through the tracheal opening (Fig. 292).

In the employment of upper tracheoscopy, even when general anesthesia is induced, the larynx should be cocainized to prevent the shock always attendant upon manipulation of the sensitive mucous membrane of that region.

FIG. 290.—UPPER BRONCHOSCOPY, SITTING POSITION.

Killian's instruments have been slightly modified by Guisez, of Paris, who has also devised various forceps, hooks, etc. (Figs. 293–299), for the extraction of foreign bodies.

External palpation of the laryngeal cartilages, of the trachea, and the surrounding tissues of the neck is often of material assistance in the

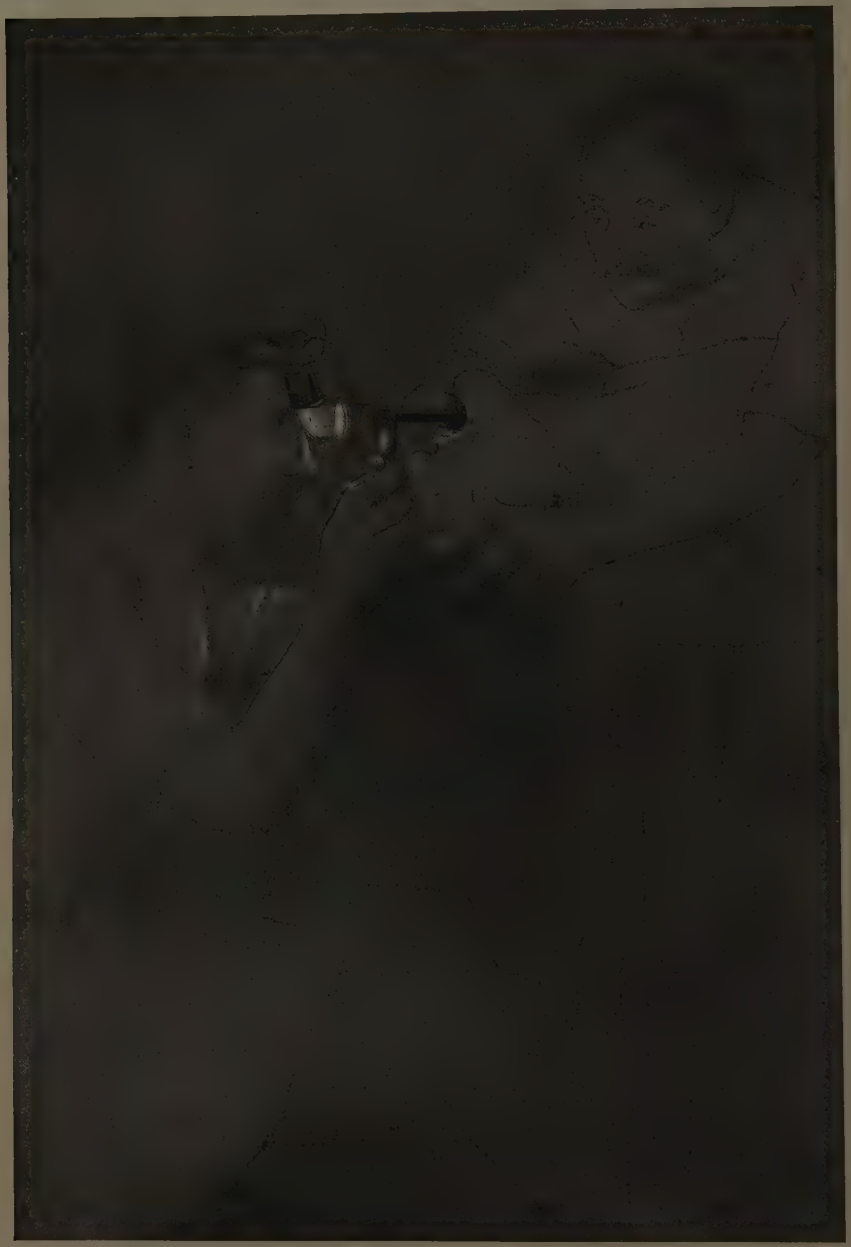

FIG. 291.—UPPER BRONCHOSCOPY, DORSAL POSITION.

diagnosis of fractures, tumors, or glandular metastases, as well as of perilaryngeal or peritracheal inflammations or abscesses.

The use of the *x*-rays is frequently of the greatest service in localizing metallic or bony foreign bodies in the larynx, trachea, or bronchi.

FIG. 292.—LOWER BRONCHOSCOPY, DORSAL POSITION.

It is also of value in certain cases of suspected new growth, especially if the tumor is of a density greater than the surrounding tissues.

CONGENITAL MALFORMATIONS OF THE LARYNX AND TRACHEA.

Bland-Sutton has stated that, of all organs, the larynx is the least liable to malformation.[6] Morell Mackenzie has reported a case of *bifid epiglottis* associated with a cleft palate and distinct fissure between the arytenoids, extending downward and involving the posterior surface of the cricoid.

Congenital stenosis of the glottis due to the presence of a *laryngeal web* or membrane between the vocal cords at the anterior commissure has been reported by v. Bruns, Lennox Browne, and others. The deformity is best seen by the laryngeal mirror during inspiration, when the vocal cords are separated. The condition may give rise to

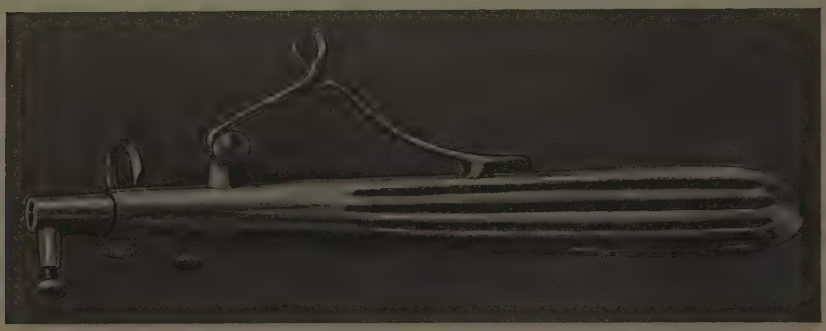

FIG. 293.

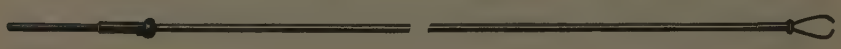

FIG. 294.

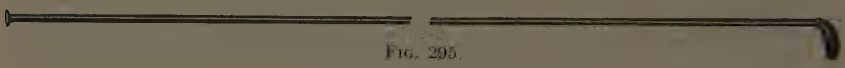

FIG. 295.

FIG. 296.

FIGS. 293–296.—GUISEZ'S HOOKS AND FORCEPS FOR THE EXTRACTION OF FOREIGN BODIES.

no symptoms; generally, however, there is weakness in the voice and dyspnea on severe exertion. Occasionally the dyspnea may be so marked as to necessitate tracheotomy or intubation.

The **treatment** of this condition consists in longitudinal division of the web to the anterior commissure by means of a laryngeal knife, followed by a limited period of dilatation by bougies or the O'Dwyer tubes.[3]

Congenital air-cysts of the larynx or trachea (aëroceles) have been reported by Ledderhose and others. They generally occur as hernial diverticula of the mucous membrane from the sides of the air tube or, more rarely, through some cartilaginous or membranous defect in the median line.

A distended sacculus laryngis or ventricle may produce an intralaryngeal aërocele; or, by protruding through the thyrohyoid membrane, it may appear in the tissues of the neck. Intrathoracic lateral aëroceles are rare and have been thought by some to represent supernumerary bronchial rudiments.

The **symptoms** of aërocele are, as a rule, unimportant. If large, however, they may give rise to stenosis and require surgical treatment. The diagnosis is generally established by the presence of an elastic compressible tumor intimately connected with the air tube, which enlarges

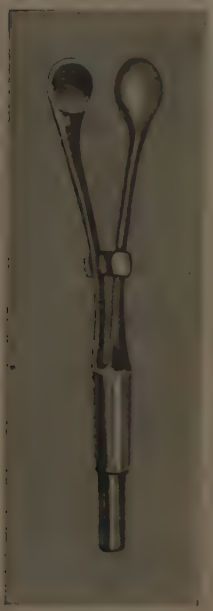

Fig. 297.

Fig. 298.

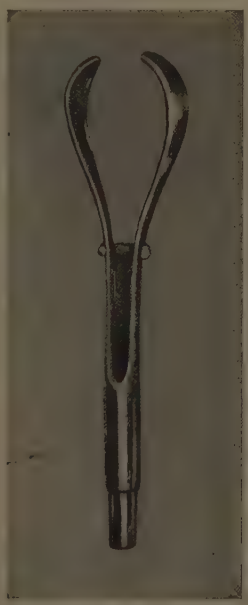

Fig. 299.

Figs. 297–299.—Guisez's Forceps for the Extraction of Foreign Bodies.

as a result of straining efforts, as coughing or crying. When treatment is required it should consist in a careful dissection and removal of the sac, ligation of the pedicle, and, when this is possible, leaving the wound partly open and packed with sterile gauze to avoid the development of emphysema.

INJURIES OF THE LARYNX AND TRACHEA.

Burns and **scalds** of the larynx and trachea are generally, if not always, associated with similar lesions of the buccal and pharyngeal mucous membranes. They result from the inhalation of flame or hot air by persons confined in burning buildings, by the custom of lighting fires with kerosene oil, by the sudden ignition of illuminating gas, and as a result of explosions or the escape of steam. Occasionally such injuries are the result of swallowing hot liquids or corrosive fluids. As

in other parts of the body the injury may be followed by an acute hyperemia, edema, and necrosis of tissue.

The **symptoms** of a burn or scald of the larynx are essentially those of a laryngitis and edema; pain increased on swallowing or phonation, hoarseness, loss of voice, and dyspnea. Profound shock and respiratory failure occur in some cases, due, as shown by Crile, to reflex phenomena from irritation of the superior laryngeal nerves.

The laryngeal mirror will generally disclose redness, edema, and often necrosis of the mucous membrane of the epiglottis and arytenoepiglottidean folds.

The **treatment** should consist in laryngeal rest, the external application of cold, and an early tracheotomy if the symptoms indicate progressive edema and stenosis.

Contusions of the larynx and trachea may be caused by blows or falls upon some hard object, but are usually the result of violence applied to the front of the neck, in wrestling, boxing, or fighting.

The elasticity of the cartilages in early life will admit of the application of considerable force without fracture. As a result of a contusion of the larynx or trachea the mucous membrane may be wounded, ecchymoses may appear, and more or less edema develop. The symptoms are, as a rule, insignificant and require no treatment. Occasionally there may be hoarseness or loss of voice from temporary paralysis of the vocal cords and, in rare instances, dyspnea. The occurrence of a severe grade of shock resulting in loss of consciousness or death has been observed in a number of instances in connection with contusions of the larynx without evidence of fracture or other important anatomic lesion. The term *concussion of the larynx* has been applied to this condition, which is similar in its manifestations to the severe shock following rough handling of the mucous membrane of the upper part of the larynx, to which Crile has referred in his essay upon shock.[1] The treatment of this condition is the same as for shock in general, as the local conditions in the absence of dyspnea require no special attention.

Fractures of the larynx and trachea may be caused by the same forms of direct violence enumerated under the causes of contusion. In addition to these, indirect violence may result in these fractures, such as falls or blows upon the head, straining effort during parturition, violent coughing, etc. Hyperextension of the neck may result in complete fracture of the trachea, and crushes and other severe injuries of the thorax have been known to produce fracture of the lower segment of the trachea or the pulling off of one bronchus. As fractures of the laryngeal cartilages are fully described in the chapter on Fractures (Vol. II., p. 154), only *fractures of the trachea* will be considered in this section.

This is an exceedingly rare injury. The commonest form is a complete transverse separation, in which the separated ends are generally retracted, leaving a distinct interval. Longitudinal and oblique ruptures are occasionally seen and are generally the result of lateral compression or severe intratracheal pressure.

The **symptoms** of tracheal fracture are localized pain, dyspnea, subcutaneous emphysema, and cough with frothy, bloody expectoration. Palpation may occasionally aid the surgeon by detecting irregularities in the normal contour of the tube or points of actual separation.

The symptoms of intrathoracic rupture or fracture of the trachea or one of the bronchi are generally obscured by those of the associated lesions. The presence of dyspnea, bloody expectoration, and emphysema, developing upward from the mediastinum and root of the neck, are strongly suggestive of this lesion. If the condition of the patient permits, the employment of tracheoscopy would doubtless establish the diagnosis.

The **prognosis** in fracture of the trachea is unfavorable, the mortality being over 50 per cent.

The **treatment** of fracture of the trachea should be early tracheotomy. The danger of delay is largely due to the rapid development of emphysema, which renders the operation exceedingly difficult.

In performing tracheotomy an effort should be made to insure the distal extremity of the tube reaching a point below the injury. When the ordinary tracheal cannula is found to be too short, a firm rubber tube may be employed, reaching, if necessary, to the bifurcation of the trachea. After the introduction of the tube, tears or rents in the trachea may be sutured.

Dislocations of the laryngeal cartilages have been reported in a few instances. They are caused generally by direct violence applied to anterior or lateral portions of the neck. von Bruns, in 1904, stated that uncomplicated dislocation of the arytenoid had not been recorded. Dislocations of the arytenoids, however, are occasionally observed associated with fractures of the larynx.

Dislocation of the thyroid cartilage at the cricothyroid articulation may occur. In many instances the displacement is partial and is due to a relaxed condition of the cricothyroid membrane. These luxations may occur as a result of muscular action in the act of swallowing, vomiting, etc. There is generally an acute pain localized over the articulation, with difficulty in breathing and a noticeable deformity best appreciated by palpation.

As a rule reduction is easily accomplished by gentle manipulation aided by extension or flexion of the head. In some instances the act of swallowing brings about spontaneous reduction.

WOUNDS OF THE LARYNX AND TRACHEA.

In the great majority of instances wounds of the larynx and trachea result from gunshot injuries, stabs, bayonet thrusts, and suicidal or homicidal attempts. In rare instances wounds of the upper air tube may be caused by accidents with knives, broken glass, or as a result of trauma from explosions, the bites of animals, etc.

For a description of the symptoms and treatment of *cut throat*, which includes a large proportion of these injuries, the reader is referred to Chapter XXXVII. (p. 309).

The **diagnosis** of wounds of the larynx and trachea presents no difficulties. The presence of an external wound in the neighborhood of the air tube, associated with cough, bloody expectoration, and subcutaneous emphysema, is sufficient to establish the diagnosis. In the absence of this characteristic group of symptoms the laryngoscope may be used, and in certain rare instances of suspected injury to the thoracic portion of the trachea, tracheoscopy may serve to clear the diagnosis.

The **prognosis** of *gunshot* or *stab wounds* of the larynx and trachea is grave. Death may result soon after the injury by asphyxia from the inhalation of blood or from edema. Dyspnea from emphysema is, as a rule, less serious than in simple fracture, owing to the ready exit for the air furnished by the external wound. The danger to life from pneumonia after such injuries is considerable. Cicatricial contractions may follow and cause grave stenosis. Permanent hoarseness or aphonia not infrequently results from injuries to the vocal cords, the muscles, or the recurrent laryngeal nerve.

In the **treatment** of these injuries the surgeon should seek first to arrest hemorrhage and provide for the free entrance and egress of air to the lungs. A free exposure of the wounded area of the larynx and trachea is essential. In most instances it is desirable to perform a tracheotomy below the seat of injury, after which the wounds may be accurately sutured if there has not been too great a loss of substance or too great injury to the parts. If the loss of tissue has been considerable, it is often desirable to maintain the patency of the tube during healing by granulation by the introduction of a rubber tube into the lumen of the larynx and trachea above the cannula. This may be held in place by a few sutures. To facilitate removal a loop of silk should be passed through the upper extremity of the tube, carried outward through the mouth, and attached to the ear or cheek by adhesive plaster. When the wound has progressed to a point where the tube is no longer needed, the retaining sutures may be cut and the tube easily withdrawn by means of the silk loop. In these severe cases subsequent dilatation to prevent or overcome recontraction should be made by the use of the O'Dwyer intubation tubes.

FOREIGN BODIES IN THE AIR-PASSAGES.

The presence of a foreign body in the larynx, trachea, or bronchus is a source of great danger. This accident is of frequent occurrence. It occurs somewhat more often in children than in adults. In the great majority of instances the body is held in the mouth and aspirated into the air tube by a spasmodic inspiration, the result of an unexpected fit of coughing or laughter. Not infrequently during the act of swallowing food, incomplete coördination of the muscles will force the partly swallowed morsel of food into the laryngeal vestibule, from which it may be carried downward by a sudden and violent inspiratory effort.

Substances ejected from the stomach during an attack of vomiting

may occasionally be drawn into the air-passages. In rare instances, as a result of gunshot wounds, bullets may be drawn into the larynx and trachea, and broken fragments of tracheal tubes have been known to separate and be drawn downward. Profound intoxication from alcohol, coma from poisonous drugs, and general anesthesia undoubtedly act as predisposing causes of this accident. The anesthetist should always remove false teeth, tobacco, etc., prior to anesthesia and also remember the danger of vomited matters being drawn into the air-passages during anesthesia.

The effects produced by foreign bodies in the air-passages depend upon many factors. Large angular and rough bodies are more frequently arrested in the larynx than small smooth or round substances. The latter are more often drawn into the trachea or one of the bronchi. Pointed substances, as pins, splinters of wood, or sharp fragments of bone frequently become arrested in the trachea or one of the bronchi. If not of sufficient size to prevent the entrance and egress of air, they give rise to little or no discomfort unless ulceration occurs. Oval or rounded substances, on the contrary, are frequently driven upward and downward by the current of air. When driven against the vocal cords they produce violent cough, profound spasm, and dyspnea. When drawn downward so as partially to occlude the bronchial orifices they produce a sense of suffocation. Bodies which swell by the absorption of moisture, as beans, peas, dried kernels of nuts, etc., often give rise to progressively increasing symptoms as their size is augmented. Soluble substances, on the other hand, as pills or bits of candy, produce progressively diminishing discomfort. Complete plugging of one of the large bronchi causes atelectasis and renders that lung functionless; the plugging of one of the smaller tubes produces a similar but more limited lesion. Crile has shown experimentally that foreign bodies lodged in the upper part of the larynx, by irritation of the terminal branches of the superior laryngeal nerves, may give rise to serious and often fatal collapse from reflex inhibitory action upon the heart and respiration.[1] Bodies lodged in the inferior laryngeal compartment and trachea practically never produce reflex phenomena other than cough.

A wound of a bronchial tube by a foreign body may cause an interstitial emphysema, which may extend upward to the tissues of the neck. Of the hundreds of substances which have been reported as being found in the air-passages, those more frequently encountered are pins, nails, tacks, teeth, fragments of bone, coins, beans, masses of meat, toy whistles, bits of china or glass, and buttons.

Lennox Browne states that about 20 per cent. of foreign bodies are arrested in the larynx, about 50 per cent. pass into the trachea, and about 25 per cent. lodge in the bronchi.[3] The right bronchus receives by far the largest number, owing to its larger size and the fact that its lumen is more nearly in a line with that of the trachea.

The **symptoms** of a foreign body in the larynx vary with the size, shape, and consistence of the offending substance. A comparatively

soft body may be jammed between the vocal cords and produce complete asphyxiation and death without cough.[9] When the lumen is not completely occluded, the first symptoms are pain, violent cough, and spasmodic efforts at respiration. Sudden cardiac and respiratory failure will occasionally follow the irritation of substances lodged in the upper larynx. The grave condition is indicated by pallor, cold perspiration, a feeble, rapid pulse, and the absence of respiratory effort. It is never observed where the body is situated below the larynx.[9]

If the object is sharp or rough, edema quickly develops, with dyspnea, aphonia, vomiting, and salivation. In many instances these bodies may be spontaneously expelled with complete relief of all symptoms. In some cases the body may give rise to ulceration, necrosis of the cartilages, and eventually be discharged into the esophagus or through an external wound. Movable bodies in the trachea produce violent cough and spasm by contact with the under surface of the cords. Fixed bodies produce localized pain and tenderness to external pressure. If the body is lodged in one of the bronchi the location of the pain is a valuable sign, indicating the side on which the lesion is present. Respiratory embarrassment is present when one of the larger tubes is completely plugged.

The **diagnosis** is materially helped by physical examination of the chest. von Bruns states that in complete occlusion of a bronchus, the respiratory murmur is absent upon that side, while the normal resonance is preserved. Even in incomplete occlusion the respiratory excursion and the breath sounds upon the affected side are distinctly lessened. If the symptoms are not too urgent the employment of the *x*-rays will often be of the greatest service when the foreign body lies below the larynx, for by their use any metallic or bony substance can be located with accuracy.

When the body is lodged in the larynx or upper trachea, laryngoscopy, when practicable, will serve to establish the diagnosis; if below the larynx, tracheoscopy may be employed.

The **prognosis** in these cases is grave. von Bruns, from all available statistics, estimated the general mortality to be about 33 per cent. In a fair number of cases the foreign body is coughed out soon after its aspiration. In others it becomes encapsulated and gives rise to little or no discomfort.

Mackenzie reported a case where a fragment of bone had remained in the lung for sixty years without severe impairment of health. In the great majority of instances, however, the presence of a foreign substance in the air tube carries with it grave danger to life, unless it can be removed before it gives rise to serious pathologic changes. In general it may be stated that the deeper the foreign body is lodged the greater the mortality. The length of time before surgical intervention is also an important factor in prognosis, as the earlier operations are far more successful than those undertaken after edema, emphysema, or infection has occurred.

In the **treatment** of this condition it is necessary to divide the cases

into two distinct classes: those in which the foreign body is lodged in the larynx either between or above the true cords and those in which it lies in the inferior laryngeal compartment, the trachea, or one of the bronchi.

In the first class, with very few exceptions, extraction through the natural passages by means of the laryngoscope and forceps is possible. Occasionally in cases of extreme urgency masses of meat or other occluding substances have been removed from the entrance to the larynx by the forefinger introduced through the mouth. The plan of inverting and shaking the patient or striking him violently upon the back has occasionally been successful. When the body is known to be situated below the vocal cords, endolaryngeal methods should be abandoned and tracheotomy performed. A movable body will generally be expelled through the tracheal wound by the coughing of the patient. The use of general anesthesia in these cases, especially where marked respiratory obstruction exists, is often attended with grave risk, for the reason that one of the first effects of the anesthetic is to paralyze the extraordinary muscles of respiration, which throws the work of supplying oxygen upon the ordinary muscles, already inadequate to the task. For this reason the employment of local anesthesia is advisable. Preliminary cocainization of the laryngeal mucous membrane should precede any interlaryngeal manipulations.[9]

Bodies arrested high in the trachea or lower larynx are best removed through a low tracheotomy wound; either by extraction with forceps or by pushing the substance upward through the larynx into the pharynx. If the body is impacted low down in the trachea or in one of the bronchi, lower tracheobronchoscopy may be carried out through the wound and the foreign substance removed by Killian's or Guisez's forceps, hooks, or a strong electromagnet.

Prior to 1897, foreign bodies lodged in the bronchi were generally regarded as beyond the possibility of surgical removal, except by operation through the chest wall. As practically all such attempts in the past had been followed by fatal results, the prognosis in these unfortunate cases was grave in the extreme.* In March, 1897, Killian succeeded in removing a piece of bone from a bronchus by means of his bronchoscopic apparatus and demonstrated that bodies could be seen and removed even from the smaller subdivision of a bronchus.

Since the publication of his report the method has been extensively employed in these cases. In addition to a number of other successful cases by Killian, Guisez in 1903 successfully removed a nail from the third bronchial division by means of lower bronchoscopy and forceps.[9] Schroetter recently reported 2 cases, in one of which he removed a tack from the right bronchus without anesthesia by the help of upper bronchoscopy.[10] During the past year Kob reported 2 successful cases of removal of a body from the bronchus by lower bronchoscopy. In one of the cases tracheotomy had been performed three

*Goeltz has recently reported the successful removal of a foreign body from the right bronchus by means of an incision through the anterior chest wall.

months before. From these and other successful cases it will be seen that Killian has made a most valuable contribution to the therapeutics of this condition.

Regarding the choice of method in a given case, Moure has recently expressed the opinion that general anesthesia should always be employed in children; that tracheotomy and lower bronchoscopy should be used in late cases where there already exist well-marked pathologic changes in the lung; upper bronchoscopy being limited to early cases or where little or no reaction has resulted from the presence of the foreign body. In all of these operations the greatest gentleness should be exhibited, as rough handling and prolonged manipulation frequently give rise to edema of the mucous membrane, leading often to a fatal pneumonia.

INFLAMMATORY DISEASES OF THE LARYNX AND TRACHEA.

In considering the acute inflammations of the larynx a distinction should be made between the catarrhal forms and those due to trauma, the presence of foreign bodies, or to septic conditions. The former are, as a rule, mild in character and only in exceptional instances give rise to symptoms requiring surgical intervention, while the latter are generally more important and often require prompt and radical operative treatment.

Catarrhal Laryngitis.—The term catarrhal laryngitis signifies an inflammatory process limited to the mucous membrane of the larynx and not involving the submucous areolar tissue or the cartilages. It occurs at all ages and results from exposure to cold and wet, from overuse of the voice, from the inhalation of irritating particles suspended in the atmosphere, and from intestinal and other forms of toxemia. It is frequently encountered as an early symptom of certain general diseases, as measles, German measles, syphilis, and scarlet fever, and as a later manifestation of small-pox and typhoid fever.

The pathologic changes are, as a rule, limited to the mucous membrane, which is reddened and slightly thickened.

In the adult type the mucous membrane of the epiglottis, the arytenoepiglottidean folds, the false cords, and the ventricular cavities are chiefly involved in the early stages; that covering the true cords showing these changes at a later period. In the infantile type the lesion is, as a rule, more pronounced in the subglottic region. In the laryngitis associated with the exanthemata, more or less characteristic lesions, similar to those observed on the skin, can often be seen by the laryngoscopic mirror.

The **symptoms** of catarrhal laryngitis are cough, hoarseness, aphonia, and in children spasm of the glottis, dyspnea, and stridor. Pain is occasionally present, especially in speaking or swallowing. In the simple, uncomplicated cases due to exposure or overuse of the voice there is, as a rule, no fever or other constitutional disturbances.

The **treatment** of this condition in the adult should consist in rest

of the voice, astringent sprays, steam inhalations, and other purely medical measures.

In the infantile type when dyspnea is present (simple laryngeal croup) an emetic often gives prompt relief. In exceptional cases, however, the difficulty in breathing may become so marked as to necessitate intubation or tracheotomy.

Traumatic Laryngitis.—In this condition the laryngeal inflammation is the direct result of injury and the condition of the mucous membrane will vary according to the character and extent of the trauma. The presence of a foreign body, as a pin, fish-bone, or splinter of wood, in the pyriform sinus or vestibule may give rise to a simple inflammation of the neighboring mucous membrane, which quickly subsides after the removal of the offending body. In other instances, where larger or more irritating bodies are wedged in the larynx, ulceration may occur and a rapidly developing edema may complicate the condition.

In contusion or fracture of the larynx the mucous membrane may be the seat of ecchymoses or submucous hematomata, and in the severe forms it may be lacerated and the resulting hemorrhage by aspiration may give rise to pulmonary complications.

The symptoms and treatment of these conditions have already been described under Injuries of the Larynx, and will not be repeated, other than to state that the important factor in all is the liability to laryngeal obstruction, either by the presence of the foreign body or by the development of edema, which must be met by tracheotomy or intubation.

Diphtheria or Pseudomembranous Laryngitis.—Without entering into a detailed consideration of diphtheria, it may be stated that involvement of the larynx and trachea occurs in a fairly large proportion of the cases. Of 220 fatal cases Osler reports involvement of the larynx in 75; of the trachea, 66.

In rare instances the disease begins in the larynx and may afterward extend upward to the pharynx and downward to the trachea and bronchi. In the majority of instances, however, where there is laryngeal diphtheria, the laryngeal involvement is secondary to the pharyngeal lesion.

Of 286 cases of pseudomembranous laryngitis investigated by Park and Beebe, in 229 the Klebs-Löffler bacillus was demonstrated, in 57 they were not present or the culture was unsatisfactory. The membrane found in laryngeal and tracheal diphtheria is more commonly fibrinous in character than that present in the pharynx. It is grayish-white in color and, as a rule, easily detached from the underlying mucous membrane, which appears inflamed and bleeding, but rarely ulcerated. The disease occurs with greatest frequency in children under fifteen years of age. It occurs in epidemics which vary greatly in severity. It is distinctly contagious.

The **symptoms** of pseudomembranous laryngitis are, in the beginning, those of an acute catarrhal laryngitis. There is slight hoarseness, cough, a sense of burning and itching of the throat, and some discomfort on swallowing. These symptoms are generally aggravated at night and are not infrequently relieved in the morning. Later there occurs slight

dyspnea, especially on inspiration, which soon increases until more or less difficulty is experienced both in inspiration and expiration. The voice is lost and cough produces spasm of the glottis.

As the obstruction increases the child experiences more and more difficulty in respiration. The skin becomes cyanosed, the expression anxious, there is marked restlessness, the accessory muscles are finally called into action, and the picture is then one of impending suffocation. In addition to the above-mentioned symptoms there are generally, but not always, present evidences of pharyngeal diphtheria, the temperature is moderately elevated, the pulse accelerated, and there is often nasal discharge and glandular enlargement of the neck.

The **diagnosis**, as a rule, presents no difficulties, even without the aid afforded by the laryngeal mirror, which is often serviceable in adults and older children, not only to establish the diagnosis, but to estimate the changes in the location of the membrane and the occurrence of edema. As a rule the use of the laryngoscope is contra-indicated in young children.

In the **treatment** of laryngeal diphtheria one must always recognize two factors: first, the measures necessary to combat the disease and its resulting toxemia; second, the treatment of the laryngeal obstruction. In the treatment of the general disease are included those local and general remedies which serve to disinfect locally, as gargles, sprays, and local applications of peroxid of hydrogen, very weak solutions of bichlorid of mercury (1: 10,000 to 1: 5000), carbolic acid, etc., together with an abundance of nourishing food, stimulants, and the *early use of antitoxin.*

Undoubtedly under the use of these remedies a fair number of cases of laryngeal diphtheria will recover without surgical intervention. As soon as the dyspnea becomes continuous, however, and especially if the patient shows signs of deficient oxygenation of the blood, measures should at once be undertaken to overcome the laryngeal stenosis. Two operative procedures are available: intubation of the larynx by means of the O'Dwyer tubes and tracheotomy. Both give about the same percentage of recoveries.

von Bruns and other European surgeons favor tracheotomy in the majority of cases. Most American authorities favor intubation for the following reasons. The technic is simpler. The operation can be performed without an anesthetic and in less time. There is less danger of hemorrhage into the trachea and lungs. There is less danger of bronchopneumonia. There is less danger of an extension of the membrane downward, which is favored by the presence in the trachea of the open wound and the more movable cannula. Parents will more readily consent to the less hazardous procedure. On the other hand, in intubation there is often danger of the child's coughing the tube out of the larynx; under these circumstances suffocation may take place before it can be replaced. In certain cases when the chief obstruction lies in the upper trachea intubation will not relieve the stenosis. In other rare instances children cannot swallow while the laryngeal tube is

in place and are thus deprived of the food and stimulants necessary to combat the toxemia of the disease.

In my own opinion the best results will be obtained by the employment of intubation when this procedure relieves the obstruction without interfering with feeding and where the tube can be normally retained. In all other cases tracheotomy should be the operation of choice.

In considering the **prognosis** of these operations one must have in mind the fact that they simply overcome the danger of death from suffocation, that they can in no way influence the progress of the disease, except that by insuring free respiration the normal resistance of the individual is perhaps increased and the liability to bronchopneumonia is lessened.

Before the general employment of antitoxin the death-rate after operation ranged from 60 to 75 per cent. Since the introduction and general use of antitoxin the mortality has been lowered to between 30 and 35 per cent.

Edema of the Larynx.—Under this heading will be included *inflammatory edema*, submucous laryngitis, or that form of laryngitis in which the pathologic process extends to the submucous areolar tissue, resulting in tumefaction due to the presence in the tissue of serum or other products of inflammation; and also *non-inflammatory edema*, the result of cardiac or renal lesions, venous obstruction, pulmonary tuberculosis, and malignant disease. The chief factor in all of the cases is an edematous swelling of the lining membrane of the larynx producing respiratory obstruction. The most frequent seat of this lesion is that portion of the mucous membrane which covers the aryteno-epiglottidean folds, as the amount of submucous areolar tissue is most abundant in this situation. The mucous membrane of the true vocal cords, on the other hand, rarely takes part in the process, for the reason that it is closely adherent to the fibrous structure of the cord, with but little or no intervening areolar tissue.

In the inflammatory edema the mucous membrane is often acutely injected, red, and swollen; when the infection is a pyogenic one the infiltrating exudate may become purulent and simple or multiple abscess result. In non-inflammatory edema the mucous membrane is pale or has a slightly yellowish tinge. It has a watery myxomatous appearance similar to that seen in a nasal polyp.

Among the causes of inflammatory edema must be included the causes of acute laryngitis: trauma, the inhalation of superheated air or steam, and the presence of foreign bodies. Erysipelas of the face is occasionally complicated by an extension of the process to the fauces and larynx. Under these circumstances obstruction from edema may develop with great rapidity.

The presence of infection or suppuration in neighboring tissues, as deep cellulitis of the neck or Ludwig's angina, will often give rise to edema of the larynx; and venous obstruction from the presence of a new growth or as a result of a surgical operation frequently favors the development of edema.

The **symptoms** of edema of the larynx may often be preceded for a variable period by those of a simple laryngitis, a foreign body, trauma, or some other of the predisposing causes. When edema develops the voice becomes weak and deep in pitch, there is moderate cough, and a feeling of some foreign substance to be expelled. Respiratory embarrassment develops and may increase with great rapidity. At first inspiration is impeded, then both inspiration and expiration. In the majority of cases the point of obstruction lies at the superior aperture of the larynx and is caused by swelling of the aryteno-epiglottidean and the interarytenoid tissue. On laryngoscopic examination these tissues are seen to fall together during inspiration, obscuring the vocal cords. In the rarer subglottic edema the reddened mucous membrane from either side of the larynx occasionally may be seen below the vocal cords to come together, leaving a narrow longitudinal aperture. While the cords may become reddened, they rarely if ever show much thickening, certainly not enough to impede respiration.

In many cases of edema from severe trauma, erysipelas, or Ludwig's angina the development of the symptoms is so rapid that death may ensue before a surgeon can be summoned. Lennox Browne reported an instance where a man suddenly developed an edema while sitting in the waiting-room of a public dispensary where he had gone for treatment of another disease. In this case death occurred in a few minutes before the attending staff could perform tracheotomy.

The **prognosis** in conditions complicated by edema of the larynx is always grave. When the possibility of edema has been foreseen, however, and measures are taken to insure prompt operative relief as soon as the obstruction to respiration becomes marked, death from this cause is exceptional. It is rather in those cases in which edema is impending, but in which no preparations are made to meet the emergency promptly, that the fatalities occur.

The **treatment** of edema of the larynx before marked obstruction occurs should be by removal, if possible, of the cause. Extraction of foreign bodies, replacing displaced fragments after fracture or dislocation of the cartilages, releasing neighboring foci of pus, or treating pharyngeal infections should be undertaken in suitable cases. The use of steam inhalations, especially when combined with the vapor of benzoin, is highly recommended in the milder forms due to catarrhal conditions. Scarification by means of a well-guarded laryngeal lancet is regarded by Lennox Browne as a most valuable procedure, often producing complete relief in a few hours, even in cases of impending suffocation. In all cases, however, in which the life of the individual is threatened no time should be wasted by a trial of milder methods, as tracheotomy is positively indicated as the only rational treatment.

Chondritis and **perichondritis** of the laryngeal cartilages occur as a result of primary infection by means of wounds, compound fractures or surgical operations, as a result of secondary infection from the extension of ulcerative processes within the larynx (carcinomatous, tuber-

culous, syphilitic, etc.), to the cartilages, or by means of metastatic infection from some remote septic focus.

As cartilage is one of the most poorly nourished tissues of the body it follows that any infection or injury of the cartilage itself or of the perichondrium which furnishes its chief blood supply is likely to be followed by necrosis. When this takes place pus appears between the cartilage and its perichondrium. The necrosed area of the cartilage gradually separates from the healthy portion and finally lies as a loose sequestrum in the subperichondrial abscess. Rupture of this abscess with or without spontaneous discharge of the sequestrum may take place at any stage of the process. Occasionally when the sequestrum is small it may disappear by molecular disintegration and be discharged as pus. When the process is extensive the larynx and sometimes the trachea may be greatly deformed by loss of tissue, and serious impairment or interference with the functions of phonation and respiration may result.

In rare instances, especially when due to the syphilitic virus, resolution may take place without abscess formation, leaving only a thickened area over the affected cartilage.

The rupture of a subperichondrial abscess may take place into the pharynx or esophagus, into the air tube, or externally. When rupture occurs in two directions fistulæ may result. Occasionally the discharge of a cartilaginous sequestrum into the larynx may give rise to obstruction, spasm, or edema, requiring prompt surgical interference.

The **symptoms** of chondritis or perichondritis are localized pain, cough, embarrassment of respiration, hoarseness, aphonia, and dysphagia. The laryngoscope may reveal the presence of a circumscribed swelling encroaching upon the lumen of the tube or the discharge of pus from a sinus or ulcerated area. External deformity due to the swollen cartilage or abscess may sometimes be apparent on inspection and localized tenderness may be detected by palpation. Redness of the skin, edema, and fluctuation are present when the abscess points externally. Fever is rarely a prominent symptom, but is occasionally present in the metastatic cases.

Regarding the **prognosis** in these conditions, it may be stated that the danger to life, in cases which can be carefully watched and intelligently treated, is small. In neglected cases, on the other hand, the danger is often considerable, as suffocation may result from edema or the sudden rupture of an abscess into the air-passages. The prognosis regarding restoration of function is exceedingly unfavorable. In traumatic cases and those which are due to malignant disease or chronic ulcerative processes the primary condition may add other unfavorable factors.

The **treatment** depends largely upon the cause. In syphilitic chondritis the judicious employment of energetic antisyphilitic treatment will occasionally bring about a cure and will generally limit to a considerable extent the destructive process. Endolaryngeal operations, as the incising of an abscess and the removal of a fragment of necrosed

cartilage, are indicated when the disease is readily accessible. Abscesses pointing externally should be opened and drained as in other similar surgical lesions. In the graver cases, where the disease is extensive and inaccessible by these simple measures, tracheotomy followed by thyrotomy and thorough inspection of the interior of the larynx with the removal of all diseased tissues is the most rational treatment. The danger of subsequent cicatricial contraction and stenosis should always be remembered and measures employed to combat this tendency.

Tuberculosis of the Larynx.—Primary tuberculosis of the larynx is an exceedingly rare disease. Secondary tuberculous lesions in the larynx are far more frequent, being observed by Heinze in about 50 per cent. of 1226 autopsies performed at the Leipzig Pathologic Institute upon patients dying from tuberculosis.

The disease occurs most frequently in young male adults between twenty and thirty years of age. In a large proportion of the cases (about 50 per cent.) the lesions are unilateral and the side of the laryngeal lesion generally corresponds with that of the chief pulmonary focus.

The disease generally begins as a submucous infiltration, which later ulcerates, often at several points, giving rise to multiple superficial erosions which may coalesce, making a more or less extensive ulcerated area. In some instances the ulcers penetrate deeply into the tissues, giving rise to perichondritis and necrosis of the cartilage. Exuberant granulations occur in and about the ulcerated areas and may cause laryngeal stenosis. Laryngeal and tracheal tumors due to tuberculosis have been described by Mackenzie and others. These may appear as polypoid or cauliflower excrescences. The site of tuberculous ulceration is most commonly the vocal cords, posterior wall, the arytenoepiglottidean folds, or the arytenoid cartilages.

Involvement of the crico-arytenoid articulation occurs in a certain number of cases, also paralysis of the muscles from infiltration or from nerve pressure.

The **symptoms** of tuberculous laryngitis are hoarseness, a painful spasmodic cough, and dyspnea. The presence of any or all of these symptoms in a person with pulmonary tuberculosis should awaken suspicion of a laryngeal involvement.

On laryngoscopic examination in the early stage of the affection there will generally be noticed an abnormal pallor of the mucous membrane, thickening of one or both arytenoids tapering off toward the junction of the fold with the epiglottis, and multiple superficial ulcerations on one of the vocal chords. At a later period more extensive areas of ulceration will be seen involving other portions of the larynx with exuberant granulations and diminished movement or paralysis of one or both cords. The epiglottis may become thickened or ulcerated, and finally evidences of perichondritis will be seen. The characteristic features of tuberculous ulceration of the larynx are early involvement of the arytenoids, the superficial character of the ulcers, and the great pain experienced on swallowing and coughing.

The **treatment** of this condition is not very satisfactory, owing to

the almost constant association of pulmonary lesions. When the involvement of the lung is extensive, hygienic and palliative measures only are to be recommended. Residence in a mountainous district with an outdoor life will often bring about temporary improvement. The inhalation of a spray of iodoform dissolved in ether is of positive value in many cases. Applications of orthoform are said to give relief in some instances. When the disease is primary or when the involvement of the lung is not extensive, the local use of lactic acid or formalin to the ulcerated areas has occasionally been successful. Gleitsmann has recommended thorough removal of a discrete lesion by means of the curet.[11]

Laryngotomy and thorough surgical removal of the diseased tissue has been successful in a few instances, notably one reported by Hopmann, in which the patient, a clergyman, continued his work for many years after the operation. In the later stages, where stenosis has resulted from involvement of the cartilages, tracheotomy will be necessary to avoid suffocation.

Lupus of the Larynx.—Although the lesions of lupus are tuberculous in nature, the clinical manifestations of this form of the disease are so different from those of the ordinary type of tuberculous ulceration that a separate consideration is desirable. The disease is an exceedingly rare one and is generally associated with lupus of the skin and pharynx. The condition is characterized by the presence of nodular lesions, chiefly on the epiglottis and upper portions of the larynx. These ulcerate slowly and extend gradually, finally involving large areas. Healing of the ulcerated area wil often occur in one place while it extends to another. The scars contract and cause stenosis and great deformity. Pain is rarely present in laryngeal lupus and the presence of the disease is for that reason often unknown to the patient until changes in the voice occur or respiratory embarrassment develops as a result of cicatricial stenosis.

In the **treatment** of lupus of the larynx the same measures that have been found useful in the cutaneous forms of the disease are to be advised. Thorough cureting followed by the application of lactic acid has been successful in a few instances, also the use of the *x*-rays and the Finsen light. Subhyoid pharyngotomy with surgical removal of the diseased area is to be recommended in suitable cases. When stenosis develops, tracheotomy should be performed.

Syphilis of the Larynx and Trachea.—The larynx may be the seat of both the early and late manifestations of syphilis. During the secondary stage of the disease hyperemia of the laryngeal mucous membrane may occur, also superficial erosions similar to the mucous patches of the mouth and pharynx.

The symptoms caused by these lesions are identical with those of a subacute catarrhal laryngitis and are promptly relieved by mercurial treatment. In the tertiary period gummatous lesions may occur, either as discrete infiltrated areas or as a diffuse thickening of the entire mucous membrane and submucous tissues. The most frequent seat of

these lesions is the epiglottis, next in frequency comes the vocal cords and posterior commissure. The ulcers of syphilis are generally caused by the necrosis of a gummatous infiltration and are characterized by an absence of pain, by their tendency to extensive destruction of tissue, and the dense contracting cicatrices which they produce in the process of healing.

The crico-arytenoid joints may become ankylosed, the cartilages eroded, and perichondritis and abscesses develop. In rare instances condylomata may form upon the epiglottis or in the other portion of the larynx and give rise to stenosis. Muscular paralysis from infiltration of the muscles or from nerve lesions are not infrequent in the severer types of the disease. With all of these lesions, particularly when the cartilages are involved, acute or chronic edema may occur and cause stenosis. Similar lesions may occur in the trachea and give rise to acute or chronic stenosis. A frequent seat of gummatous infiltration of the trachea is just above the bifurcation; next in frequency is the upper segment of the tube, the middle portion being rarely affected.

The **symptoms** of laryngeal syphilis are in the early stages the symptoms of any laryngeal irritation; cough, hoarseness, aphonia, and slight difficulty in respiration. Dysphagia may occur when the epiglottis is extensively involved or destroyed. In the ulcerative stage the expectoration of pus, mucopus streaked with blood, or of masses of necrotic tissue may be noted. On laryngoscopic examination one will often be surprised at the extent of the lesion, which is often wholly out of proportion to the discomfort experienced by the patient; absence of pain being here as elsewhere characteristic of the tertiary lesions of syphilis.

Dyspnea in uncomplicated syphilitic lesions of the larynx and trachea is generally a late symptom. In mixed infection, however, it may occur suddenly, as in the septic inflammations.

The symptoms of laryngeal involvement in congenital syphilis are often overlooked, owing to the difficulty of successful laryngoscopy. Changes in the voice and dyspnea occurring in a syphilitic infant should always awaken suspicion of a gummatous or ulcerative lesion and lead to an endolaryngeal examination.

The **prognosis** in syphilitic disease of the larynx and trachea depends largely upon the care exercised in the treatment of the early stages of the affection. Under favorable conditions when the patient can enjoy the advantages of early judicious treatment the risk to life is small and the majority will avoid the grave complications, as stenosis and destruction of the cartilages, which so often follow neglect.

The **treatment** should consist of the early employment of energetic antisyphilitic medication combined with appropriate hygienic measures. Surgical operations are generally required only for the suppurative complications and the often resulting stenosis. The former have been described under the treatment of Chondritis and Perichondritis; the latter will be considered under the treatment of Stenosis.

Rare Forms of Chronic Inflammation of the Larynx.—**Actinomycosis** may occur as a primary disease of the larynx, but in the few cases recorded it was generally secondary to some neighboring focus. It usually affects the cartilaginous structures, producing the characteristic lesions of perichondritis with ulceration. The overlying skin becomes indurated and brawny. The diagnosis is impossible until the characteristic yellow particles containing the ray fungus can be demonstrated in the secretions. Surgical treatment combined with the use of iodid of potassium or the copper salts is indicated.

Leprosy of the larynx has been observed in a few instances. The lesions are found most frequently on the epiglottis or in the interarytenoid region. These tissues become thickened and nodular, occasionally ulceration takes place; cicatrices follow, become atrophied, and appear as silvery white scars. As the disease produces local anesthesia the usual symptoms of laryngeal irritation are absent. Dyspnea, however, may occur at any stage and require tracheotomy.

Scleroma of the larynx and trachea, a chronic inflammatory condition of the mucous membrane and submucous tissue occurring in the infraglottic portion of the larynx and occasionally in the trachea. It is rarely seen in America, the majority of the cases occur in immigrants from Russia, Poland, and Germany.

While the disease is generally associated with a similar condition in the nose and nasopharynx (rhinoscleroma), a number of cases are on record where it occurred as a primary lesion in the larynx. In a case recently reported by Emil Mayer the lesion consisted in an oval mass resembling a new growth, which was attached beneath the right cord and "projected into the larynx, diminishing its lumen by about one-half."

The disease is undoubtedly infectious, moderately contagious, and is probably due to a specific micro-organism which has been described by Mandlebaum as "a mucoid Gram-negative, capsulated bacillus."

The early symptoms of the laryngeal lesion are those of any benign growth or chronic inflammation. Later the enlargement of the mass may give rise to stenosis. Removal of the growth gives temporary relief, but it is doubtful if a permanent cure is ever attained.

CHRONIC STENOSIS OF THE LARYNX AND TRACHEA.

The causes of acute primary laryngeal stenosis have already been described in the preceding sections.

As a result of trauma, ulcerative processes, or operative interference with the air tube, cicatrices may form secondarily and give rise to a chronic form of stenosis, which is most rebellious to treatment and frequently taxes the skill of the surgeon and the patience of the victim to the utmost. Practically all of these patients come to the surgeon wearing a tracheal cannula.

In a recent communication upon this subject[12] John Rogers enumerates the following cicatricial deformities resulting from tracheotomy

which may give rise to stenosis and retained tube: (*a*) Contraction of the posterior soft part of the trachea following separation of the anterior segments by the cannula; (*b*) dislocation of the cricoid forward and downward, especially when the fistula is through or close to it; (*c*) overriding of the cut anterior ends of the tracheal rings, especially if the fistula is to one side of the median line; (*d*) contraction of the trachea around the cannula, due to sloughing of the cartilages or rings; (*e*) spur formation posteriorly (as after enterostomy), especially in combination with contraction of the posterior soft portion of the trachea, or dislocation of the lower segment forward and the upper backward, or both.

Of the other causes of stenosis following tracheotomy or intubation he mentions hypertrophic subglottic laryngitis, and the presence of granulation about the cannula or intubation-tube, the former he regards as one of the most frequently encountered causes of retained tube.

Hypertrophic subglottic laryngitis occurs most frequently as a result of tracheotomy in diphtheritic laryngitis. The mucous membrane is hyperemic and greatly thickened from infiltration with many small round cells. It is velvety in appearance and bleeds easily on contact. There are no ulcerations. In consistency it is somewhat firmer than an edema. This condition greatly reduces the lumen of the tube and may produce complete stenosis. It is easily dilated, however, and, as a rule, does not interfere with the introduction of the largest-sized intubation-tube.

The **symptoms** of ordinary stenosis of the larynx and trachea have already been described and will not be repeated. In hypertrophic subglottic laryngitis the symptoms differ somewhat from the other forms and may be best illustrated by giving a brief clinical history of a case recently under the joint care of Dr. Rogers and myself.

A man fifty years of age was operated upon for the removal of a cicatricial nodule low down in the cervical portion of the trachea, the result of a former tracheotomy. The trachea was opened by a 5-cm. longitudinal incision, the obstructing mass removed, and a tracheal cannula introduced in the lower angle of the wound. On removing the cannula several days later it was found that the patient was unable to breathe through the larynx. Laryngoscopic examination of the larynx and upper trachea which had been perfectly open and free before the operation showed the mucous membrane reddened and greatly thickened, especially in the subglottic portion. The condition was thought to be a moderate laryngitis with edema and the cannula was, therefore, reintroduced. One week later, on again attempting to remove the cannula, the larynx was found to be absolutely occluded. The largest-sized intubation-tube was introduced, but immediately coughed out. The cannula was replaced and allowed to remain for another week, with the same result on removal. For the next eight weeks a series of specially made intubation-tubes was tried until one of the plugged tubes to be described later was retained for two or three days at a time, when the pain and difficulty in swallowing necessitated its removal and the replacement of the cannula.

For a number of weeks the removal of the intubation-tube, which was of the largest size, would immediately be followed by almost complete stenosis. Perseverance in the treatment for several months, however, finally brought about a cure. At no time was there any ulceration, fever, or other evidences of constitutional disturbance.

The **prognosis** in cicatrical stenosis of the larynx is exceedingly unfavorable when there has been extensive destruction of tissue and where a tracheal cannula has been worn for a long period. In the milder cases and in the cases of hypertrophic laryngitis and tracheitis a favorable result can generally be obtained if the treatment is diligently followed. In many instances, however, the patients become weary of the long treatment and suffering due to the frequent dilatations and prefer to resort to the permanent use of the tracheal cannula.

In the **treatment** of this condition both surgeon and patient must be prepared for a long series of discouraging attempts. In a few milder grades of stenosis, as in non-ulcerative syphilitic interstitial laryngitis, cures may be brought about by gradual dilatation by the use of the intubation-tubes of O'Dwyer. Various sizes and shapes must be tried until one is found which can be retained without great discomfort. This is to be worn for a variable period and then replaced by larger sizes until the stenosis is fully dilated. It may then be discontinued, being introduced for twenty-four hours once or twice a month. In the majority of instances, however, the patient comes to the surgeon wearing a tracheotomy cannula.

FIG. 300.—RUBBER TUBE FOR MAINTAINING PATENCY OF TRACHEA AFTER THYROTOMY AND TRACHEOTOMY.

Thyrotomy and incision of the trachea to the fistulous opening with removal of the obstructing bands and tissue is indicated in a certain number of cases. When this procedure is followed I introduce a rubber tube (Fig. 300), corresponding in size to the lumen of the trachea, and close the tissue over it. It should extend from the entrance of the larynx to the tracheal cannula at the lower angle of the wound. From the upper extremity of the rubber tube a loop of silk passes upward out of the mouth and should be made fast to the ear or cheek by adhesive plaster. The tube may be retained in place by one or two fine catgut sutures which are easily broken if for any reason it is desirable to remove the tube. The use of this tube prevents collapse of the larynx and

trachea, prevents overriding of the cut edges, and therefore serves to maintain the full patency of the air tube until the processes of repair are well under way. In two or three days both cannula and rubber tube are removed. Subsequent recontraction must be guarded against by the occasional introduction of a full-sized intubation-tube.

When thyrotomy is not indicated for the removal of definite obstructing masses, rapid dilatation by the introduction of urethral steel sounds, passed from below upward through the tracheal fistula, followed by the use of a full-sized intubation-tube in the manner described above, constitute the best treatment.

When difficulty is experienced in retaining the tube, Rogers' plugged or clamped special tubes should be employed (Figs. 301 and 302).

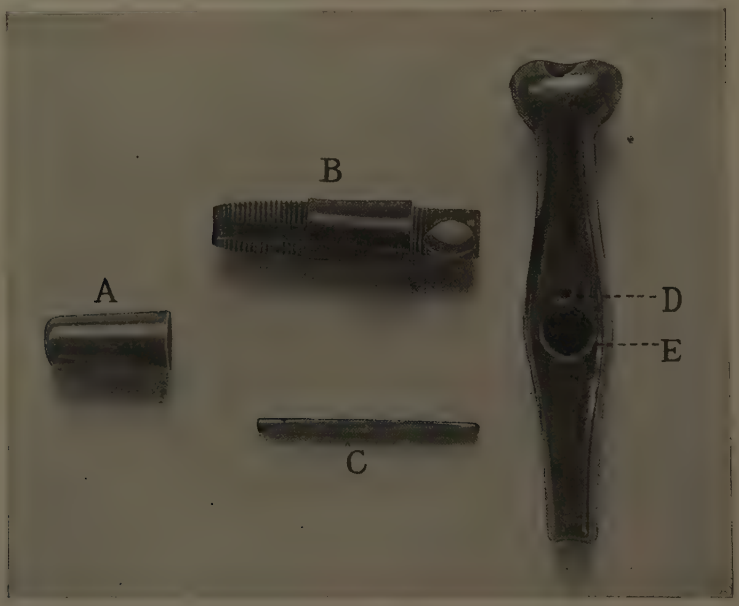

FIG. 301.—ROGERS' PLUGGED TUBE.

By a "plugged" tube is meant one fitted with a plug (B) made to screw accurately into a perforation (E) in the anterior wall of a normal or special tube through a tracheal fistula. The plug is perforated at its inner end by a hole which exactly corresponds in size with the lumen of the tube. The plug is provided with a retaining pin (C), which, when the plug is in place, prevents it from rotating and so obstructing in the slightest way the lumen of the tube. By previous measurement the tube has a hole bored in its anterior wall (E), which when the tube is inserted lies opposite the tracheal fistula. Into this hole the plug is then screwed and "pinned" at right angles to the tube. A cap (A) is then screwed down over the outer end of the plug to hold the pin in place. By a "clamped" tube is meant one fitted with a detachable pair of metal clamps (B) made on the principle of an obstetric forceps.

In the sides of the tube are cut grooves (C), which, when the instrument is in place, lie at the level of the tracheal fistula. Through this the clamps are made to grasp the tube and are then held in place by a collar (A) screwed down around them until the collar touches the tube. The plugged or clamped tube is a guarantee against auto-extubation and at the same time keeps the tracheal fistula from closing.

After removal of the cicatricial bands or masses of dense fibrous tissue through a thyrotomy incision von Mikulicz has successfully employed glass tubes to prevent collapse of the trachea or recontraction. Alopy successfully treated an obstinate tracheal stenosis by removal of the scar tissue and the implantation of Thiersch's skin-grafts upon the

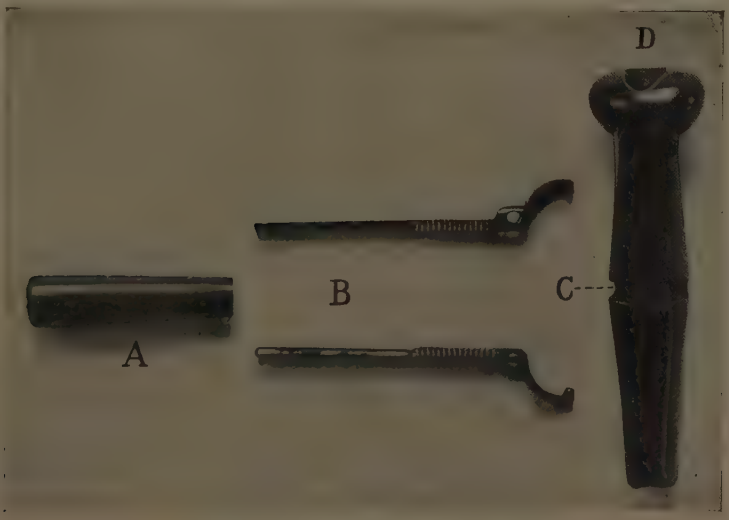

FIG. 302.—ROGERS' CLAMPED TUBE.

internal raw surfaces of the tube.[13] Plastic operations, by means of skin and bone or skin and cartilage flaps, have been employed by Schimmelbusch and Koenig to repair losses of tissue in the trachea. Circular resection of a strictured area of the trachea with end-to-end suture has been successful in the hands of Keen.

NEW GROWTHS OF THE LARYNX.

According to Semon, about 88 per cent. of all tumors of the larynx are benign, 12 per cent. malignant. Of the benign tumors of the larynx papillomata and fibromata are the most common. Statistics of different authorities vary somewhat as to which is the commonest. Mackenzie and Lennox Browne hold that papillomata are more frequently observed, while Schrötter and von Bruns maintain the opposite view. Angiomata, lipomata, adenomata, myxomata, and retention cysts are occasionally observed. Cartilaginous outgrowths from the thyroid or cricoid have been reported, but are exceedingly rare.

Papillomata occur at any age, but are most frequently encountered in children and in individuals before middle life. They may be single or multiple. Solitary papillomatous growths are generally situated upon the vocal cords or in the anterior commissure, rarely on the interarytenoid fold. When multiple they appear on one or both cords in the ventricular spaces on the epiglottis, more rarely in the subglottis region or in the trachea. They vary considerably in size, from that of a pin's head to a tumor the size of a large raspberry. Multiple papillomata are common in early childhood. In these cases the entire laryngeal membrane may be covered by warty growths greatly impeding free respiration. When seen by the laryngoscope they appear as irregular reddish or pinkish elevations which may be pedunculated or sessile. In old papillomatous lesions the red or pink color may be wanting, owing to a lessened vascularity.

Fibromata, like papillomata, occur most frequently upon the vocal cords or in the anterior commissure. Unlike papillomata, however, they occur more frequently in adult life and are generally single. They rarely grow to a large size and rarely cause obstruction to breathing. Two varieties occur—the hard fibromata, which appear as oval, smooth nodules with broad bases, and the soft variety, which may be pedunculated, forming laryngeal polypi. Occasionally the soft fibromata may be lobulated. They are always covered by unbroken mucous membrane, the color of which may be deep red or pale pink, according to the degree of vascularity. Angiomata may occur on the vocal cords and are generally irregular in contour and red in color. Cysts are commonest on the epiglottis.

The **symptoms** of benign neoplasms of the larynx vary according to their situation and the size of the growth. Small tumors when situated elsewhere than upon the true cords may give rise to no symptoms. The presence of a small tumor on the vocal cord causes, as a rule, an alteration in the voice which may vary from a slight hoarseness, noticeable only on overuse of the voice, to complete aphonia. In some instances only the singing voice will be affected, ordinary conversation giving no sign of a laryngeal lesion. When the growth is large and overlaps the glottic opening, more or less dyspnea may be present. This symptom is more commonly observed, however, in children, owing to the small size of the laryngeal fissure and to the fact that the growths are often multiple. Cough is present in a fair proportion of the cases and is often spasmodic in character. Pain is rarely a prominent symptom in the absence of laryngitis; when inflammation is added, however, pain, irritable cough, and bloody expectoration may be present. As a rule papillomata produce more symptoms of laryngeal irritation than fibromata and the other rarer forms of new growth.

The **diagnosis** of tumor of the larynx is rarely possible without the aid of the laryngeal mirror or one of Killian's tubes. Occasionally in children traction and forcible depression of the tongue may expose the epiglottis and multiple papillomata be seen.

The **treatment** of benign growths of the larynx should be by thor-

ough surgical removal. Undoubtedly papillomata have occasionally disappeared spontaneously, and in a few instances the frequent use of sprays or inhalations of alcohol and other agents has been followed by marked improvement or cure, but experience has shown that too much reliance must not be placed upon these methods.

In the great majority of instances in adults removal is best accomplished by means of the snare, cutting forceps, or curet, through the natural passages guided by the laryngeal mirror. It must be remembered, however, that this requires expert training and only those who have had the advantage of this training should attempt endolaryngeal operations upon these growths. In young or nervous children, in cases of angiomata or subglottic growths, and in some cases of multiple papillomata, especially when the tracheal mucous membrane is involved, the disease should be attacked by external incision through the thyroid cartilage with or without section of the trachea. This should always be preceded by a low tracheotomy and measures should be taken to prevent the aspiration of blood into the lungs. With the entire laryngeal and tracheal mucous membrane exposed the individual tumors should be removed with small curved scissors and their bases touched with the actual cautery or trichloracetic acid.

Subhyoid pharyngotomy may be employed for the removal of tumors situated at the entrance of the larynx. It has the advantage that there is little or no danger of subsequent loss of voice, which is always to be considered when thyrotomy is performed.

Malignant growths of the larynx are much rarer than benign neoplasms. They occur with greater frequency in males and, as a rule, late in life. Carcinoma is of more frequent occurrence than sarcoma, the proportion being about 12 to 1.

Malignant tumors of the larynx have been divided by Krishaber into the *intrinsic* tumors or those which occur wholly within the larynx, surrounded by the thyroid and cricoid cartilages, and the *extrinsic* tumors, or those which occur at the superior aperture of the larynx, and are not wholly surrounded by these cartilages. The former class includes growths upon the vocal cords or at the anterior commissure, those situated on the false cords or in the ventricular spaces, and those which occur in the subglottic region. The latter class includes growths on the epiglottis, the aryteno-epiglottidean folds, the interarytenoid space, and those occurring in the pyriform sinuses.

This classification is an important one for the reason that intrinsic growths, as a rule, develop slowly and remain for a long period confined to the laryngeal cavity. Lymph-node involvement occurs late and visceral metastasis is extremely rare. Extrinsic growths, on the other hand, grow more rapidly, frequently spread to neighboring tissues, and metastasis occurs at an early period. The reason for this difference is to be found in the arrangement of the lymphatics. The vocal cords which exhibit practically no submucous tissue are but poorly supplied by lymphatics. The lymphatics from the upper surface of the vocal bands pass upward, gradually becoming more abundant until at the

superior aperture of the larynx, interarytenoid and aryteno-epiglottidean folds they are very numerous. From these situations and also from the epiglottis and pyriform sinuses several collecting trunks pass outward through the thyrohyoid membrane. One or more of these enter a node situated beneath the posterior belly of the digastric muscle, the others pass to other substernomastoid nodes further down. The lymphatics of the subglottic region of the larynx are less abundant than those of the supraglottic region. They, however, become more abundant in the lower portion of the space and form several large collecting trunks which emerge in front and at the sides of the air tube. Those in front pass outward through the cricothyroid membrane; some descend in front of the isthmus of the thyroid to the pretracheal node, others pass outward to the internal jugular chain. The lateral trunks pierce the cricotracheal membrane near the junction of its posterior and lateral portions and enter nodes of the recurrent chain following the recurrent laryngeal nerve. All eventually enter the jugular or supraclavicular nodes. It will thus be seen that the vocal cords form, as it were, the watershed of the laryngeal lymphatic system. Growths situated here extend very slowly along the lymph-channels. The farther it is removed from the true cords the more likely is a given malignant neoplasm to infect the anatomically related lymph-nodes (Fig. 303).

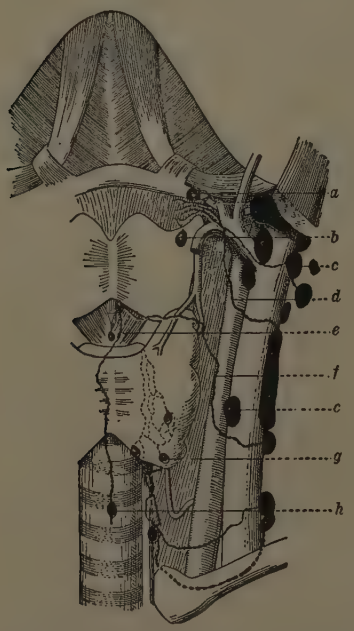

FIG. 303.—LYMPHATICS OF THE LARYNX.

a, *b*, Thyrohyoid glandular nodules placed in the course of the collecting trunks coming from the pharyngeolaryngeal sinuses; *c*, *c*, glands of the internal jugular chain; *d*, collecting trunk of the superior pedicle; *e*, *f*, collecting trunk of the middle pedicle; *g*, gland of the recurrence chain; *h*, pretracheal gland. (Most.)

In this connection it should be mentioned that the above statements apply chiefly to carcinomatous growths, as sarcoma of the larynx as in other situations shows little tendency to spread by the lymphatics, metastasis occurring generally by the blood-vessels.

Carcinoma of the larynx may occur in any part of the mucous membrane. Its most frequent seat, however, is on the vocal cords, considerably more than half the cases occurring in this region. The other situations in the order of their frequency being the false cords, the interarytenoid fold, the epiglottis, the aryteno-epiglottidean folds, the ventricles, and the subglottic region. On the vocal cords the disease generally begins as an elevated nodule covered with intact mucous membrane, as a warty growth, closely resembling benign papilloma, or as a superficial ulceration.

In the earlier stages there is little in the appearance of the lesion to distinguish it from the purely benign growths which it resembles. Later there occurs a zone of peripheral hyperemia and infiltration with edema. As the growth advances ulceration commonly occurs, generally at a point of irritation as the free margin of the vocal cord. Extension of the process to the muscles, the arytenoid joint, or pressure on the recurrent nerve by lymph-node metastasis causes a diminished movement or paralysis of the affected vocal cords. When the cartilages are finally involved necrosis may occur and perichondritic abscess and fistula follow. In the extrinsic variety the primary appearance of the growth may be the same; the development is, however, more rapid and it frequently extends to the mucous membrane of the pharynx, esophagus, or base of the tongue, with early lymph-node involvement. Carcinoma of the larynx is rare in individuals under forty years of age. It is commonest between fifty and sixty, but it has been observed in youth and in extreme old age.

According to Lennox Browne males are affected much more frequently than females, the proportion being 10 to 1. It seems to be more prevalent among the well-to-do than in those in the humbler walks of life.

Sarcoma of the larynx is a comparatively rare affection. It occurs rather more frequently as an extrinsic than an intrinsic growth. The number of accurately reported cases is as yet too small to formulate any definite statements regarding the comparative frequency in the different portions of the larynx. It has, however, been frequently reported as arising from the vocal cords, the aryteno-epiglottidean folds, the pyriform sinus, and from the cartilages.

The most frequent variety is the hard spindle-cell tumor which takes its origin from the submucous tissue. It grows slowly as a round oval or flattened nodule resembling the benign fibroma. This is the form most frequently seen on the vocal cords. Round-cell sarcoma develops more rapidly and occurs more commonly on the aryteno-epiglottidean folds or in the pyriform sinuses. These tumors are exceedingly malignant, are softer in consistence, and by their rapid growth and larger size more frequently give rise to stenosis. Chondrosarcoma and myxosarcoma are among the rarer forms found in the larynx. Sarcomata are less prone to ulceration than carcinomata. They rarely invade the lymphatics, but the more cellular varieties extend to neighboring tissues and give rise to infiltration of the cartilages and soft parts, causing necrosis, perichondritis, abscess, and fistula.

The **symptoms** of malignant disease of the larynx vary with the primary seat of the lesion. In growths occurring on the vocal cords the first symptom is an alteration in the character of the voice, generally a slight hoarseness, without pain or cough. If the growth occurs on the epiglottis, on the aryteno-epiglottidean or interarytenoid fold, pain on swallowing may be the first manifestation of the trouble.

Small growths occurring in the pyriform sinus, on the false cords, or in the subglottic region, on the other hand, may be symptomless for a considerable period of time. At a later period all malignant growths

give rise to laryngeal irritation, evidenced by pain, cough, and dyspnea. The pain in the later stages is distressingly acute and is not infrequently referred to the region of the ear on the affected side. This, together with the constant irritating cough, often prevents sleep, while the distress which accompanies swallowing results in insufficient alimentation and rapid wasting. Complete aphonia and dyspnea develop in neglected cases, and death from suffocation may occur unless relief is offered by a timely tracheotomy.

The **diagnosis** of malignant disease of the larynx is generally difficult and often impossible in the early stages of the affection without the aid of the microscope.

The occurrence of an unexplained hoarseness in an individual of the cancer age should at once awaken suspicion of a malignant growth. The suspicion is strengthened if the patient is a male between forty and sixty years and if the laryngoscopic picture is that of a lesion on the vocal cord without laryngitis. The occurrence of a small area of redness surrounding the lesion, the presence of ulceration or a diminished mobility of the affected cord, renders the diagnosis of malignancy probable. As the successful treatment of this disease depends upon early diagnosis and prompt surgical measures, removal of a portion or the entire growth by endolaryngeal methods should be practised at the earliest moment, with a view to microscopic examination and accurate diagnosis (Semon).

While it is possible in this manner to arrive at an early and accurate diagnosis in the majority of instances when the growth is situated upon the vocal cords or above, in the subglottic tumors, it is often difficult or impossible to remove enough of the growth to render accurate microscopic diagnosis possible. While the microscope will generally reveal the true nature of the growth if a sufficiently generous fragment is removed for examination, it occasionally happens that the findings are not sufficiently characteristic to warrant a positive diagnosis. Under these conditions one must determine the probable character of the disease by the clinical history, laryngeal appearances, age and sex of the individual, and the ability to exclude other neoplasms or constitutional conditions. As gummatous infiltration may in the early stages closely resemble malignant disease, the exhibition of iodid of potassium for a limited period will be of service in doubtful cases.

In the **prognosis** of malignant disease of the larynx it must be borne in mind that death is the inevitable result in every case unless the disease can be radically removed by surgical operation at an early period. Before the discovery of the laryngoscope there were no recoveries, for the reason that the disease was not recognized until too late for radical treatment.

Prior to 1894 permanent cures were obtained in only 8 per cent. of the cases (Sendziak). Since that period earlier diagnosis and improved technic have resulted in a lowering of the immediate death-rate following operation, and have shown a percentage of permanent cures which compares favorably with that of malignant disease in any part of the

body. In a recently published series of 20 cases of carcinoma treated by thyrotomy and radical removal Sir Felix Semon reports 1 death and 15 permanent cures. In a recent series of 22 cases of total laryngectomy for cancer, Gluck reports only 1 operative death, and of 27 partial excisions of the larynx and pharynx, the same author reports 26 recoveries and 1 death. Permanent cures have followed many of these operations, but in most instances these operations have been performed too short a time for reliable data. While Gluck's statistics regarding his operative mortality are most encouraging, they must at the present time be looked upon as exceptional, as the majority of surgeons still regard the operation of total laryngectomy as a dangerous undertaking.

This is not so much due to shock nor to any grave technical difficulty, but rather to the fatal type of pneumonia which so frequently follows any extensive operation on the upper portion of the air tube.

Theoretically, intrinsic cancer of the larynx should show the best results from early radical surgical treatment, for the reason that the disease remains for a long period limited to the interior of the larynx, that its earliest period of growth is generally announced by an easily recognized symptom (hoarseness), and for the additional reason that a positive diagnosis can be arrived at in the majority of cases by laryngoscopy, endolaryngeal removal, and microscopic examination. While the prognosis in extrinsic cancer of the larynx is less favorable than in intrinsic disease, still recent current literature furnishes several examples of complete recovery following radical removal of such growths even after extension to the pharynx, tongue, esophagus, and lymphatic structures of the neck.

Certain authorities have strongly advised against total laryngectomy, for the reason that the operation was a mutilating one and rendered the subject unfit to associate with his fellows or to enjoy life. This view I believe to be extreme; for while cases are on record where individuals have committed suicide from grief over loss of voice, the great majority of patients, if called upon to choose between a lingering and painful death from cancer and life with a prospect of good bodily health, even without normal mouth respiration, and voice, would undoubtedly choose the latter alternative.

When laryngotomy only is performed most patients speak distinctly though with a whispering voice. In a minority of the cases a more or less normal voice is obtained, notably in a patient reported by von Bruns, who was able after this operation to continue his work as a didactic teacher for twelve years or more. After total laryngectomy most patients acquire the art of pharyngeal phonation and are able to be understood by those about them. In a patient operated upon by myself six years ago pharyngeal phonation is so distinct that she can be readily understood at a distance of 20 feet or more by those accustomed to converse with her. The use of an artificial larynx (of which there are several ingenious models) is, as a rule, unsatisfactory, as it necessitates either a pharyngeal fistula or the use of a tube passing from the tracheal cannula upward through the anterior nares to the pharynx.

In the **treatment** of malignant diseases of the larynx we must consider, first, endolaryngeal operations; second, attacking the growth by means of subhyoid pharyngotomy; third, laryngotomy; fourth, partial laryngectomy; fifth, total laryngectomy; and sixth, the use of tracheotomy, of radiant energy, or Coley's fluid in inoperable conditions. While undoubted cures have in a few instances followed the removal of malignant neoplasms by endolaryngeal methods, yet the uncertainty which necessarily attends this method and the great difficulty in estimating the extent of the disease, have induced most surgical authorities to condemn it. Attacking a malignant growth of the larynx through a transverse wound in the thyrohyoid membrane (subhyoid pharyngotomy) is inadvisable in most instances for the reason that the mortality following this procedure is higher and the approach more difficult than through the more generally employed thyrotomy or laryngotomy wounds. Since Mr. Butlin, in 1889, strongly advocated removal of early intrinsic malignant growths of the larynx by means of a median incision through the thyroid and cricoid cartilages, the operation has steadily grown in favor. It is to be advised in all early cases of intrinsic cancer where the growth is limited to one side of the larynx and where the disease involves the soft parts only.

It should be performed in the Trendelenburg or Rose position and be preceded by a low tracheotomy. The entire growth and all surrounding soft tissues should be removed to the perichondrium. The edges of the larynx should then be allowed to fall together and be held by two or three catgut sutures. The tracheal cannula may be retained for twenty-four or forty-eight hours. In the more advanced cases where the growth has slightly invaded the cartilage this may be cut away or hemilaryngectomy may be performed. In extrinsic malignant disease, removal, as a rule, should be more extensive and the regional lymphatics and lymph-bearing areolar tissue should be included. These operations are usually atypic, for the reason that considerably more than the affected portion of the larynx must be sacrificed. Gluck has recently reported a series of successful cases of extensive removal of laryngopharyngeal carcinoma in which one or more recurrences had occurred in the lymphatic system of the neck.

Total laryngotomy should be reserved for cases of bilateral malignant disease, involvement of the cartilages, extensive recurrent disease, and cases in which slight lymph-node metastasis is present. All of these operations will be described at the end of the chapter. In inoperable malignant disease of the larynx, and when for any reason the condition of the patient contra-indicates operation, the use of the *x*-rays or radium is to be advised. The favorable influence of these agents in malignant disease has been generally recognized, but as yet no facts are available which would induce one to employ radiant energy in any but the above outlined conditions. The use of the mixed toxins of streptococcus erysipelatis and the bacillus prodigiosus (Coley's fluid) should be employed in all cases of inoperable or recurrent sarcoma. Tracheotomy will be indicated in the later stages of all cases not otherwise treated.

NEW GROWTHS OF THE TRACHEA.

New growths of the trachea are extremely rare. The proportion of malignant to benign is much greater than in tumors of the larynx. Theisen in 1902 reported 135 cases of tracheal tumor, of which 89 were benign and 46 malignant.

Of the benign growths it may be said that the same varieties occur in the trachea as in the larynx. Fibroma occurs independently in the trachea, papilloma generally in association with similar growths in the larynx, and almost always limited to the upper segment of the tube. The occasional presence in the interior of the trachea of masses of thyroid tissue is well known. These glandular islands are generally in direct connection with the lateral lobes of the gland by means of prolongations from the latter through the membrane between the rings. They are found in the lateral and posterior walls, occasionally they are annular and reach such a size as to give rise to difficulty in breathing. In rare instances they undergo malignant change.

Lipomata, adenomata, chondromata, and angiomata are occasionally encountered in the trachea.

Primary carcinoma of the trachea may develop from the normal mucous membrane or from aberrant masses of thyroid tissue. Secondary carcinoma may extend to the trachea from the larynx, esophagus, thyroid gland, or from metastatic carcinomatous deposits in the adjacent lymph-nodes. von Bruns, in 1898, collected 31 cases of primary carcinoma of the trachea. This author states that the disease occurs, as a rule, in the upper and lower thirds of the tube, rarely in the middle segment, and that it occupies by preference the posterior or lateral wall. Among the 31 cases were many types of the disease, varying in appearance from isolated nodules to diffuse infiltrations of the mucous membrane or papillomatous masses. The majority, however, were medullary rather than fibrous in character.

In a case successfully operated upon by von Bruns the growth was found to be an adenocarcinoma originating in a mass of intratracheal thyroid tissue.

Ehrlich reported a primary carcinoma of the bifurcation of the trachea with prolongations entering the two main bronchi, in which the course of the disease was extremely slow. Hoffmann has recently reported an autopsy on a case of cylindric-cell carcinoma originating from the mucous glands of the trachea.

Sarcoma of the trachea is, according to von Bruns, relatively more common than sarcoma of the larynx. The tumors are generally rounded masses situated on the lateral or posterior wall and, as a rule, develop slowly. Henrici has reported the history of a patient presenting a tumor of the trachea which histologically resembled the salivary gland tumors (endotheliomata). It was described as an elongated "roller-shaped" tumor, occupying the posterior wall and attached by a broad base.

The **prognosis** in new growths of the trachea naturally depends upon the character of the neoplasm. The results in operative removal

of benign growths is generally favorable, excepting in multiple papillomata, which frequently recur in spite of thorough removal. In estimating the chances of recovery in a given new growth of the trachea requiring operative removal, one must always bear in mind the fact that there is a distinct death-rate to be reckoned with, from simple tracheotomy, independent of the risk from the procedures necessary for the removal of the growth; and that this danger is increased by the post-operative use of the tracheal cannula. Regarding the prognosis in malignant disease of the trachea it is difficult to make any positive statements, as the number of such cases which have been thoroughly extirpated is as yet too small to furnish reliable data. Theoretically early thorough removal should promise results as satisfactory as in similar growths of the larynx, for the reason that like intrinsic laryngeal carcinoma the disease is easily recognized at an early period and remains limited to the tracheal tissue for a comparatively long time, glandular and visceral metastases being infrequent.

In the **treatment** of new growths of the trachea the same general principles apply as in treatment of neoplasms of the larynx. Accessible benign tumors should be exposed by external operation, tracheal fissure, and extirpated by the knife, scissors, or curet. Malignant tumors should be exposed in the same manner, and if small and limited to the mucous membrane, may be extirpated in the same manner, removing all the soft tissue down to the fibrous and cartilaginous wall. In more extensive disease and particularly in all cases where the submucous or deeper tissues are invaded, resection of a segment of the tracheal tube is necessary. Under these circumstances, where the diseased area is sufficiently limited, subsequent end-to-end anastomosis may be performed, with restoration of normal mouth respiration. In most cases, however, the growth has advanced to such a stage as to render excision of a larger area imperative, and in these cases the lower portion of the tube should be stitched to the skin just above the sternum. von Bruns, in 1890, removed a large portion of the cervical trachea, including ten rings, for malignant intratracheal struma, his patient living six years. In inoperable cancer of the trachea and in those cases where the growth extends to the thoracic portion of the tube, tracheotomy may be indicated as a palliative measure. When the lumen of the tube is obstructed low down the use of an extra long flexible cannula may be required to reach below the obstruction.

On one occasion I was able to afford considerable relief by curetage of an infiltrating malignant growth involving the thoracic trachea, followed by the employment of a large-sized cannula.

The use of the various forms of radiant energy or of Coley's fluid may be of some value in otherwise hopeless cases.

OPERATION UPON THE LARYNX AND TRACHEA.

Endolaryngeal operations, as the extraction of foreign bodies, scarification of the mucous membrane, opening of abscesses, and the removal of accessible new growths of the larynx or upper trachea should

not be undertaken by the general surgeon unless he has had the advantage of special laryngeal training. These operations require skill in the use of the laryngoscope and special dexterity in the employment of the armamentarium of the specialist.

As the laryngeal image presents a reversed picture, one must learn to direct his instruments in the opposite direction from that seen in the laryngeal mirror. This rule, however, applies only to movements in an anteroposterior direction. In all operations upon the larynx through the natural passages the patient should be seated in front of the surgeon. The mouth should be widely open and the tongue drawn forward and held by the right hand of the patient. The surgeon should hold the laryngeal mirror in his left hand and by means of an electric head-lamp or reflector, direct a column of light to the mirror. When the laryngeal image is clearly seen in the mirror, the surgeon is then able to direct the instrument held in his right hand to any desired region of the larynx. All operative procedures on the larynx are facilitated by the employment of local anesthesia. Cocain is the most reliable agent for this purpose and may be applied by means of a spray of a 4 per cent. solution or, better, by direct application of a stronger solution by means of a cotton swab attached to a bent wire or laryngeal probang. It is well to remember that in highly neurotic individuals the anesthesia produced by cocain in the larynx and pharynx, by removing the normal sensation of the passage of air through these passages, will occasionally give rise to a sensation of pseudosuffocation causing great apprehension and positive fright. I once saw an apparently healthy and well-balanced man fall from his chair to the floor, madly clutch his throat, and insist that he was becoming rapidly asphyxiated.

Scarification of the mucous membrane in edema of the larynx and the opening of small abscesses may be accomplished with a well-guarded knife or by means of other specially constructed instruments. *Foreign bodies* are grasped by means of laryngeal forceps or extracted by hooks. Occasionally metallic substances are removed by powerful magnets. The removal of papillomata, fibromata, and other benign growths is best accomplished by suitably curved cutting forceps, of which there are many models, or by sharp curets or snares.

Before attempting the *removal of a laryngeal growth* it is desirable to train the patient to remain passive during the intralaryngeal manipulations. This is accomplished by a more or less prolonged course of preliminary treatment, consisting in the daily practise of touching the various parts of the larynx with probangs, cotton swabs, etc., until the surgeon is able to do this without exciting spasm or retching.

Intubation of the Larynx.—This operation is performed by a special set of instruments devised by O'Dwyer, which includes an introducer, an extractor, and a series of metallic or guttapercha tubes so constructed as to fit the lumen of the larynx and upper portion of the trachea, each presenting at its superior extremity a flange to rest upon the false cords (Fig. 304). As a rule no anesthetic is required. The patient, if an adult, sits in front of the operator with the head well

extended; if a child, it is firmly held in the upright position by a nurse. The mouth is held widely open by a mouth-gag and the head steadied by an assistant. A tube is selected suited to the age of the patient or the size of the laryngeal opening and its obturator screwed to the introducer. The surgeon, standing or sitting in front of the patient, introduces the forefinger of the left hand into the pharynx until the epiglottis is reached, the tongue and epiglottis are drawn well forward, and the tube easily passed along the forefinger as a guide until its inferior extremity enters the superior aperture of the larynx. The left forefinger is then placed upon the shoulder of the tube, which at the same time is pushed downward by elevating the handle of the introducer.

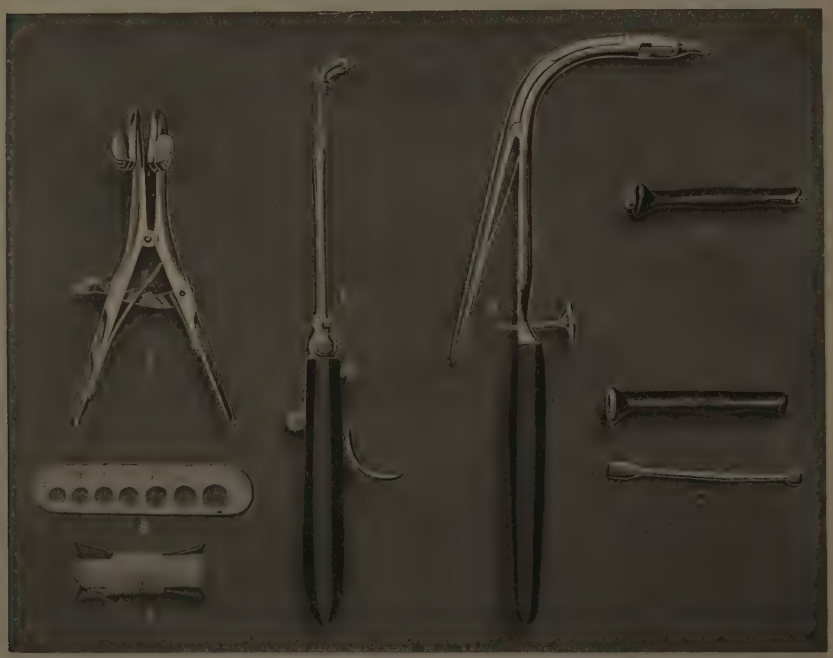

FIG. 304.—O'DWYER'S INTUBATION INSTRUMENTS.
A, Tube with obturator; B, tube; C, obturator; D, metal gauge; E, mouth-gag; F, introducer; G, extractor; H, silk cord. (Fowler.)

When well within the larynx the tube is pushed away from the obturator by a special device on the introducer, and the introducer and obturator are removed. The tube, steadied by a loop of silk previously passed through a small eye in the flange, is then pushed into place by the finger. If the patient is able to breathe freely through the tube the silk loop is divided and removed. Extraction of the tube is accomplished by introducing the tip of the extractor into the superior aperture of the tube, spreading the jaws by means of a lever on the handle, and withdrawing both tube and extractor through the mouth.

In performing this operation one should always be prepared for tracheotomy in case symptoms of suffocation arise from the dropping

of an undersized tube into the trachea or from the pushing of diphtheritic membrane or other obstructing substances in front of the tube. Another danger not infrequently encountered in this operation is sudden collapse due to inhibition of the cardiac and respiratory centers, from the irritation of the mucous membrane at the superior aperture of the larynx. This complication can be avoided by a previous cocainization of the larynx or, as Crile has pointed out, by the hypodermic injection of atropin.

Difficulty in swallowing sometimes is experienced by patients, especially adults, while wearing the tube. As a rule this can be overcome by lying upon the back with the head lower than the trunk, and by allowing the fluid to pass backward along the roof of the mouth to the posterior pharyngeal wall.

The use of special tubes in obstinate cases of laryngeal stenosis has already been described.

External operations on the larynx and trachea are required for the purpose of opening the air tube for exploration, overcoming obstruction, removal of foreign bodies, strictures or new growths, or for resecting hopelessly diseased areas.

Fig. 305.—Tracheal Cannula.

Tracheotomy is the operation most frequently performed, and as it is often required as a preliminary procedure to other operations it will be considered first. The instruments required are a dissecting set, a tracheal dilator, and a tracheal cannula (Fig. 305). General anesthesia is frequently desirable, although local anesthesia is often employed. The patient should be in the dorsal position, with the shoulders raised on a sand-bag or pillow and the head well extended. Fig. 306 will show the relation of the parts and the location of the incision in this and other median incisions in the air tube.

A median incision is made over the portion of the trachea to be opened. The sternohyoid and sternothyroid muscles are separated and the layer of fascia covering the isthmus of the thyroid gland divided. Several large veins are generally encountered, which should be divided between two ligatures. When the isthmus of the thyroid is reached it should be retracted upward or downward and the tracheal rings exposed. It sometimes happens that the isthmus of the thyroid is so voluminous that it must be partly or entirely divided in order to expose a sufficient area of the trachea. When this is necessary the bleeding should be controlled by mass ligatures, preferably introduced before division. When all bleeding has been arrested the trachea should be steadied by

the fingers or a tenaculum and the incision made exactly in the median line, after which the dilators are introduced and the cannula inserted. It occasionally happens in cases of grave emergency that the trachea has to be opened to save life before all bleeding has been arrested, and large quantities of blood are sometimes aspirated into the trachea and bronchi by the first spasmodic respiratory act, causing complete cessation of respiration. Under these circumstances, by the rapid introduction of a soft-rubber catheter to the bifurcation, with wide retraction of the tracheal wound, large quantities of blood may be drawn outward by suction or forced outward by blowing, and respiration re-established. After the cannula has been tied in place and free respiration has been assured, the upper and lower angles of the wound may be drawn together

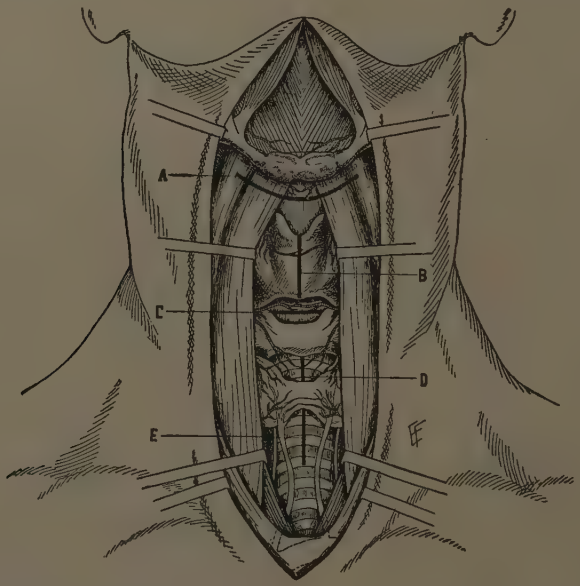

FIG. 306.—POSITION OF INCISIONS FOR OPENING THE LARYNGOTRACHEAL TRACT. (Bickham.)
A, Suprathyroid laryngotomy (subhyoid pharyngotomy); B, thyrotomy; C, laryngotomy; D, high tracheotomy; E, low tracheotomy. The corresponding skin incisions are longer than the incisions into the laryngotracheal tract.

with one or two sutures and a layer of gauze placed between the wound and the flange of the cannula.

The opening of the cannula should be protected by a few layers of gauze to filter the inspired air, the patient placed in bed in a warm room, and watched by a special nurse or trained attendant. Where there is considerable tracheal irritation the inspired air should be moistened by the employment of a croup kettle or by the use of frequently changed gauze compresses wrung out with hot water or boric solution. In emergency cases, where it is impossible to obtain a metal cannula, a rubber tube may be employed as shown in Figs. 307 and 308.

Subhyoid pharyngotomy is occasionally employed for operations upon the structures at the superior aperture of the larynx. The patient

is placed in the tracheotomy position, a transverse incision is made parallel with and just below the hyoid bone, dividing the skin, superficial fascia, and platysma. The superficial vessels are clamped and the incision deepened by a transverse section of the sternohyoid and thyrohyoid muscles, exposing the thyrohyoid membrane. The pharyngeal cavity is next opened by a horizontal incision through the membrane,

FIG. 307.—IMPROVISED TRACHEAL CANNULA, MADE FROM RUBBER TUBING. TUBE SPLIT, WITH FENESTRUM.

care being taken to keep near the hyoid bone to avoid wounding the superior laryngeal vessels and nerves which pierce the membrane on either side. Traction on the epiglottis will draw the larynx forward and give a good exposure of the structures at the entrance to the larynx and the adjacent pharyngeal wall. When the necessary operative procedures have been carried out, the pharyngeal wound should be tightly closed with catgut sutures, the muscles united, and the skin partly

sutured, a gauze drain being carried down to the suture line in the thyrohyoid membrane.

The operation gives a good exposure, but has a comparatively high mortality, and for that reason is rarely employed.

FIG. 308.—IMPROVISED TRACHEAL CANNULA MADE FROM RUBBER TUBING BENT INTO SHAPE.

Suprahyoid Pharyngotomy.—Jeremitsch and von Hacker have recently proposed this operation for the exposure and removal of new growths situated in the lower pharynx, pyriform sinuses, and the upper portion of the larynx.

A transverse incision is made just above the hyoid bone, extending on either side to the sternomastoid muscle, dividing the skin, platysma,

mylohyoid, geniohyoid, and some fibers of the digastric and hyoglossus. After all bleeding points have been secured the pharynx is opened by dividing the mucous membrane in the line of the superficial incision.

The operation affords an excellent exposure of the parts and avoids the danger of wounding the epiglottis and the superior laryngeal nerves.

The wound should be closed by layer suture, accurately approximating the divided muscles.

The operation was first suggested to Jeremitsch by the observation that cases of suicidal cut throat healed more kindly when the incision was above rather than below the hyoid bone.

While both of the above described operations can be performed in the Trendelenburg or Rose position without tracheotomy, in the majority of instances a preliminary tracheotomy is to be recommended.

Thyrotomy, Median Laryngotomy, or Laryngo-tracheotomy.—These terms are employed to designate an operation which has for its object the opening of the larynx or the larynx and trachea for purposes of examination or for the removal of foreign bodies, new growths, or cicatricial strictures. The instruments required and the position of the patient are the same as for tracheotomy. General anesthesia, preferably by chloroform, is advisable in the majority of instances, although Kocher, von Bruns, and others prefer the local use of cocain.

The first step of the operation consists in the performance of a low tracheotomy and the introduction of Hahn's sponge-covered cannula to prevent the downward flow of blood, or the patient may be placed in the Trendelenburg posture and an ordinary tracheal cannula employed. A median incision is next made, extending from a point just above the center of the thyroid cartilage downward for a variable distance, depending upon the seat of the lesion.

The soft tissues are divided in order and retracted until the thyroid cartilage is freely exposed. When all bleeding points have been clamped and ligated the laryngeal cavity is opened by a median incision through the thyroid and cricoid cartilages and, if necessary, extending downward through the upper tracheal rings. The edges of the divided cartilages are next retracted and the entire exposed portion of the mucous membrane touched with a 4 per cent. solution of cocain and adrenalin.

The subsequent steps of the operation are to be determined by the character of the lesion. In cases of unilateral intrinsic cancer Semon advises the following procedure: An elliptic incision is made surrounding the growth and from ½ to 1 cm. from its periphery. This divides the mucous membrane down to the perichondrium; the growth and the surrounding soft parts are then carefully dissected away from the cartilage and removed. All bleeding vessels should be ligated or closed by torsion. In cases of benign tumors or cicatricial bands these should be excised with the knife, scissors, or curet. After all diseased tissue has been removed and the bleeding arrested, the sponge cannula, if employed, may be withdrawn and replaced by an ordinary silver tube. The edges of the divided larynx are next approximated and held by one or two catgut sutures, and the cutaneous wound partly united and

dressed. The after-treatment should be carried out as described for tracheotomy.

Under certain conditions it may be desirable to perform thyrotomy without tracheotomy. When this is undertaken it should always be done with the head hanging downward over the edge of the operating-table (Rosé's position) or with the patient in the Trendelenburg posture.

In patients past middle life there is practically always more or less calcification of the laryngeal cartilages. Under these circumstances they are best divided with heavy scissors or the straight cutting bone-forceps. If there is no hemorrhage and no obstructing edema the tracheal cannula may be removed at the end of twenty-four or forty-eight hours.

FIG. 309.—GLUCK'S LARYNGECTOMY.

Partial or Hemilaryngectomy.—This operation is indicated in certain cases of chondritis with necrosis and in unilateral malignant disease which has progressed too far to offer any hope of radical cure by the operation just described.

The earlier steps of the operation are the same as in thyrotomy. After the larynx has been divided and its cavity explored the diseased cartilage may be cut away with scissors or the bone-forceps and the defect covered by a cutaneous flap.

Total Laryngectomy.—This operation is indicated in extensive tuberculous laryngitis without or with only slight pulmonary involvement, in bilateral intrinsic cancer in certain cases of extrinsic cancer, and in recurrent cancer after thyrotomy or partial laryngectomy. The

success of this operation in the hands of Gluck, of Berlin, has been so remarkable (a recent unpublished series of 24 consecutive cases without an operative death) that a description of his latest technic will be given.

If the whole larynx is to be removed, there is no preliminary tracheotomy, chloroform is administered, and the patient is placed in the Trendelenburg posture with the head well extended. A rectangular flap (Fig. 309), consisting of skin, subcutaneous fat, and platysma, is then turned to one side, exposing the larynx and the overlying muscles from the hyoid bone to the first ring of the trachea. The sternohyoid and sternothyroid muscles are next divided above and below and retracted to either side and the superior thyroid arteries exposed and ligated. The larynx is then skeletonized by removing the remaining

FIG. 310.—GLUCK'S LARYNGECTOMY.

muscular attachments and partly separated from the esophagus by blunt dissection. A transverse division of the thyrohyoid membrane is next made with a scalpel just below the bone and the larynx drawn well forward and its interior examined. A 10 per cent. solution of cocain is applied to the mucous membrane and a tracheal cannula introduced through the superior aperture and sutured in place. From this time the anesthetic is administered through the cannula (Fig. 305). The larynx is next separated from the esophagus, care being taken to leave as much of the pharyngeal wall as possible, and drawn downward gradually, separating the neighboring tissues from it and the upper three or four rings of the trachea (Fig. 310). A median longitudinal incision is then made over the trachea to the episternal notch, the

thyroid isthmus divided between ligatures, the larynx severed from the trachea, and the tracheal stump attached to the skin at the lower angle of the median incision. A rubber feeding tube is then introduced through the nose and pharynx into the esophagus, and the pharyngeal wound united with a double row of catgut sutures and reinforced by suturing the retracted sternohyoid and sternothyroid muscles over it. The rectangular flap is then replaced, its upper and lower margins sutured, and a generous gauze packing introduced through the unsutured lateral margin of the wound (Fig. 312). A tracheal cannula is placed in the tracheal opening and the entire neck enveloped in a sterile gauze

Fig. 311.—Gluck's Laryngectomy.

dressing. The patient is fed through the tube as soon as the stomach will bear fluids, and an effort is made to have him sit up for a part of the time after the second day.

When the disease has extended to the pharynx, base of the tongue, or upper part of the esophagus, these structures must be removed with the larynx. It occasionally happens that after thorough removal not enough pharyngeal mucous membrane is left to unite over the feeding tube. Under these circumstances a permanent pharyngeal or esophageal fistula remains.

To avoid the necessity of artificial feeding through the fistulous

opening Gluck has successfully employed a funneled feeding tube (Fig. 313), which is introduced through the mouth, past the fistula, well down into the esophagus, the upper expanded portion resting upon the base of the tongue. With this in place the patient swallows fluid and semisolid food taken into the mouth. I recently saw in Prof. Gluck's private clinic a patient from whom the larynx, the lower pharynx, and 3 or 4 cm. of the esophagus had been completely removed, who was able to feed himself by means of this apparatus without difficulty.

The low mortality following Gluck's operation is undoubtedly due to four factors: The avoidance of a preliminary tracheotomy; the lowered position of the head after the pharyngeal cavity is opened and

FIG. 312.—GLUCK'S LARYNGECTOMY.

the avoidance of leakage of blood into the trachea; the complete separation of the permanent tracheal fistula from the upper wound, and the early administration of an abundance of fluid food. The importance of several of these factors was strongly brought out by Keen in his excellent monograph upon the technic of laryngectomy, published in 1899.

The use of an artificial larynx after total laryngotomy has been attempted by many surgeons with varying success.

The older models of Gussenbauer, von Bruns, and Wolff required a permanent pharyngeal fistula, and have been pretty generally discarded, as surgeons now recognize that primary closure of the pharyngeal wound gives far better results than the older procedures. Gluck has, however, devised an ingenious apparatus which can be used after complete closure of the pharynx. It consists of a metal cap which can

be attached to the tracheal cannula; this cap has a valve through which air can be inspired, but which closes during expiration. From the upper portion of this cap a rubber tube is attached which contains a small reed. From the upper extremity of this tube another small rubber tube passes through the nose to the upper pharynx. During expiration the reed vibrates and the sound thus produced is conveyed to the pharyngeal cavity, where, by the action of the pharyngeal muscles and tongue, it is transformed into articulate speech (Fig. 314).

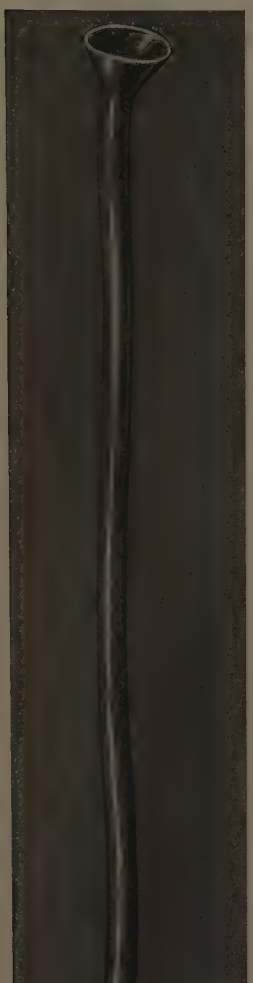

Fig. 313.—Gluck's Deglutition Tube.

As most patients after laryngectomy easily acquire the art of pharyngeal articulation, by which they can converse with those about them with comparative ease, and as any form of artificial larynx necessitates the wearing of a conspicuous mechanical contrivance which at best provides only a poor substitute for the normal human voice, the use of an artificial larynx has gradually fallen into disfavor and is to be recommended only in exceptional cases.

Resection of the Trachea.—This operation is indicated in certain cases of malignant disease, cicatricial stenosis, severe crushing injuries, gunshot wounds, and cut throat. Where the section of the trachea to be removed is limited to 4 cm. or less the two ends can generally be approximated and united, restoring the caliber of the tube and normal mouth respiration. When the removed section is greater in extent the upper extremity of the distal end must be sutured to the skin as in total laryngectomy.

The patient should be placed in the tracheotomy position and a median incision made over the portion of the trachea to be excised. The isthmus of the thyroid should be divided and the trachea exposed as described in the section on Tracheotomy. When the muscular and other tissues have been completely detached from the tube, the patient should be placed in the Trendelenburg posture and the tube severed with the knife or scissors just below the diseased area. After controlling any hemorrhage from the divided mucous membrane the distal portion of the trachea should be separated from the esophagus and temporarily fixed in the lower angle of the wound. It is generally advisable to introduce a tracheal cannula through a lower opening and through it continue to administer the anesthetic.

The second incision is made just above the lesion and the diseased area removed, care being taken in all of these manipulations to avoid wounding the recurrent laryngeal nerves. If the two extremities of the divided trachea can be easily approximated, they should be sutured together. For this chromic catgut sutures should be employed, four or five on either side. The anterior and lateral sutures should include the entire thickness of the tube. In introducing the posterior ones care

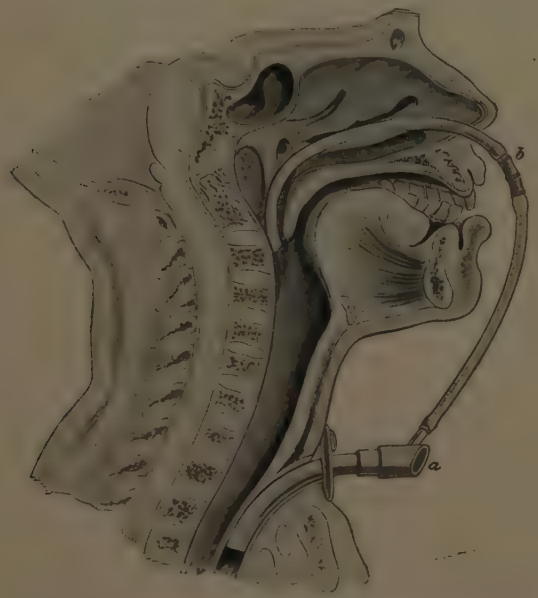

FIG. 314.—GLUCK'S PHONATION APPARATUS IN POSITION.
a, Cap with valve; *b*, voice. (von Bergmann, von Bruns, and von Mikulicz.)

should be used not to wound the esophagus. After the trachea has been sutured the soft parts should be united above and below the line of suture and a gauze packing left in the middle of the wound.

Keen has recently reported a successful case of tracheal suture, the patient being out of bed on the fourth day.

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CHAPTER XLI.

SURGERY OF THE THORAX.

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ANATOMIC CONSIDERATIONS.

The **thorax** is a cavity bounded in front by the sternum and the costal cartilages, behind by the twelve dorsal vertebræ and the ribs as far as their angles, laterally by the arches of the ribs and the intercostal muscles, superiorly by the muscles of the neck, inferiorly by the diaphragm. The latter is arched upward and encroaches considerably upon the cavity of the thorax, the highest point reaching to the level of the fifth rib on the right side and the sixth on the left. The attachment of the diaphragm to the chest wall is indicated by a line drawn from the junction of the ensiform with the sternum, backward to the eleventh dorsal spine.

The thoracic cavity contains three closed serous sacs, the right and left pleuræ, and the pericardium. The pleural cavities are situated on each side of the thorax, the space left in the center by their non-approximation is called the mediastinum. This space contains the heart and pericardium, the origins of the great vessels, the roots of the lungs, the trachea, esophagus, thoracic duct; the pneumogastric, phrenic, and sympathetic nerves.

The **lungs** are the essential organs of respiration and are placed on the two sides of the mediastinal space. Each lies free in its own pleural cavity, attached only by its root to the structures of the mediastinum. The apex of the lung rises above the level of the first rib into an oval space formed by the muscles at the root of the neck. The bases of the lungs rest upon the diaphragm and are in relation with important abdominal organs, the diaphragm alone intervening; thus the base of the right lung rests upon the right lobe of the liver, the left upon the left lobe of the liver, the stomach, spleen, and occasionally the splenic flexure of the colon. The lower limit of the pleura (costodiaphragmatic sinus) lies from $1\frac{1}{2}$ to 2 cm. above the costal attachment of the diaphragm; the lower sharp margin of the lung lies about the same distance above the bottom of the costodiaphragmatic sinus. During deep inspiration it descends nearly to the bottom of the space.

MALFORMATIONS OF THE THORAX.

Congenital malformations of the thorax are rare. They have to do with the bony framework or the muscular coverings. Of the bony malformations, median fissure of the sternum is perhaps the most

frequent. The fissure may be limited to the ensiform (bifid ensiform) or it may extend throughout the bone. The space left between the two halves of the bone is generally filled with dense fibrous tissue. Complete absence of the sternum is a rarer form of defect and unilateral absence of the bone is still less common.

One or more ribs may be absent or the development of a rib may be incomplete; in these cases the anterior portion is generally deficient. Where one or more ribs are absent the space is occupied by a dense fibrous membrane. The presence of a rudimentary rib from the first lumbar vertebra is not so very infrequent. It may be present on both sides. The junction of several ribs with the costal cartilages may be atypic, several ribs uniting with one or two cartilages, leaving abnormally wide or narrow spaces between the cartilages.

Extensive bony defects of the chest wall may result in hernial protrusions of the lungs. Pulsation of the heart or large vessels is often seen and easily felt through the thin membranous coverings.

Hernia of the lung in the cervical region has been reported, the protrusion being between the muscles at the root of the neck. These conditions rarely call for surgical treatment.

The propriety of attempting to draw together a fissured sternum and uniting the two halves of the bone with silver wire or chromic gut may be considered in an otherwise healthy child. Where large defects are present with a strong tendency toward hernia the use of celluloid or metal plates for protection should be advised. The subcutaneous implantation of a fine silver wire netting or filagree might be serviceable in these cases, as in large ventral herniæ.

Congenital malformations of the muscular coverings of the chest wall may be due to absence of certain muscles or to atrophy from deficient nerve supply, unilateral or bilateral. Absence, more or less complete, of the pectoral muscles, has been observed in a few instances; also of the scapular group or of the serratus magnus. The presence of supernumerary muscles, as the costocoracoid, the chondro-epitrochlear, or the sternalis, is frequently observed in the dissecting-room.

These abnormalities rarely, if ever, give rise to the necessity for surgical interference.

Acquired malformations of the thorax are generally the result of trauma, scoliosis, rickets, and Pott's disease, and will be considered elsewhere.

INJURIES OF THE THORAX.

Contusions of the thorax occur under a great variety of conditions, such as blows, falls, crushing injuries, the passage of the wheels of a vehicle, kicks of horses, and railway accidents. In the less important forms, the symptoms are merely those of a contusion in other parts. There are localized pain and soreness, especially marked during movements of the underlying muscles. The skin may be bruised or abraded, hematomata may occur in the subcutaneous tissue or in the muscles.

Rupture of the Lung.—The severer forms of thoracic contusions are

often associated with visceral injury, even without fracture of the ribs or sternum. As the thoracic wall is markedly elastic, a severe blow or sudden compression may greatly diminish the intrathoracic space. If at the same time the glottis is spasmodically closed and air cannot escape, rupture of the lung will take place with or without injury to the pleura. When the parietal pleura is intact a moderate rupture of the lung may give rise only to pneumothorax. If the rupture is more extensive and if one of the larger vessels is wounded in addition to the pneumothorax, hemothorax may develop. When associated with fracture of a rib and injury to the pleura subcutaneous emphysema may occur and in severe cases spread over the entire body. Subpleural emphysema may be present in injury to the lung without pleural rupture; this may extend to the root of the lung, mediastinum, and, later, appear at the root of the neck. As a secondary result of injury to the pleura, a serous exudate may develop hydrothorax, and if infection be added, an empyema or pyothorax. When the lung is involved, traumatic pneumonia is a frequent complication. In Vol. I., p. 909, a rare but startling condition, known as traumatic asphyxia, is described and illustrated.

Rupture of the diaphragm may occur as a result of a severe contusion of the thorax with or without injury to the lung. If the rent in the diaphragm is large, a hernial protusion of the stomach or of other abdominal viscera into the pleural cavity may take place. In small wounds of the diaphragm the resulting hernia is more apt to become strangulated.

The **symptoms** of severe contusion of the thorax may often be surprisingly slight, even in the presence of grave visceral lesions. In other cases, even without demonstrable injury to the chest wall or to the contained viscera, grave symptoms of shock develop and may result in death. In these cases, which are often spoken of as *concussion of the chest*, the patient may become unconscious immediately upon the receipt of the injury; the face is pale, the pulse weak or imperceptible, the respiration is shallow, and the patient may sink rapidly into fatal collapse.

These symptoms are more apt to follow injuries to the lower portion of the thorax near the heart and diaphragm, for Crile has shown by numerous experiments that traumata in these regions are followed by a greater degree of shock than those occurring in other and more remote regions of the chest and abdomen.

Involvement of the pleura is generally indicated by sharp localized pain, especially on deep inspiration. When the lung is injured there are cough and bloody expectoration. Shortness of breath, pallor, weakness, and a rapid, feeble pulse point to internal hemorrhage and compression of the lung. Epigastric pain, vomiting, and tenderness in the upper abdomen would suggest the possibility of a rupture of the diaphragm, although this lesion may be present with extensive hernia of the abdominal organs without any symptoms other than shock and a slight abdominal tenderness.

Some years ago at the Roosevelt Hospital I saw a patient admitted for a contusion of the lower thorax and abdomen. The only signs present were those of slightly embarrassed respiration and epigastric tenderness; some hours later he presented symptoms of a rapidly deepening shock. Autopsy revealed a large rent in the left leaflet of the diaphragm with the greater part of the stomach and a large loop of the intestines in the left pleural cavity.

Symptoms of intestinal obstruction may occur at any time after rupture of the diaphragm due to a loop of intestine becoming strangulated in the diaphragmatic opening. Subcutaneous hemorrhages about the head and neck are occasionally observed after severe contusions of the chest from the sudden increase of the venous pressure. Auscultation and percussion will generally reveal the signs of pleural injury, pneumonia, pneumo- or hemothorax Intestinal gurgling heard on auscultation of the chest would indicate diaphragmatic rupture with hernia.

The **prognosis** in thoracic contusions depends upon the character of the injury. In the cases associated with marked shock—concussion of the chest—the outlook is always grave. The possibility of severe visceral injury should always be remembered even where the initial symptoms are mild in character.

Schwartz and Dreyfus have recently reported 29 cases of subparietal rupture of the lung, with 16 deaths.

The **treatment** of simple, uncomplicated contusions should consist in rest and soothing applications. Shock must be energetically combated by external heat, stimulants, and, if necessary, by an intravenous saline infusion or hypodermoclysis. In cases of injury to the pleura or lung strapping the chest or the application of a tight bandage will often relieve the pain.

The treatment of subparietal rupture of the lung should consist in absolute rest by placing the patient in the position of greatest comfort and ease of respiration.

The probability of infection by external operation should be remembered and the case treated expectantly, unless infection, progressive hemorrhage, or increasing respiratory embarrassment threaten life.

In suspected cases of rupture of the diaphragm with prolapse of the abdominal viscera into the thorax, the abdomen should be opened, the prolapsed organs replaced, and an attempt made to suture the rent. The treatment of pneumothorax, hemothorax, and empyema will be considered under separate chapters.

Fractures of the ribs and sternum have been considered in the chapter on Fractures (Vol. II., p. 155).

Injuries of the pericardium, heart, and great vessels have been considered in the chapter on the Surgery of the Vascular System (Vol. V.).

Burns of the chest are considered in the chapter on Plastic Surgery (Vol. V.).

Wounds of the thorax are divided for convenience into those which

are limited to the superficial structures and those which penetrate the interior of the cavity.

Non-penetrating wounds of the chest wall may result from blows from blunt bodies (contused wounds); from cuts from knives, sabres, or glass (incised wounds); from machinery accidents, explosions, etc. (lacerated wounds), or from gunshot injuries. These may be limited to the skin and subcutaneous tissue or they may involve the muscles, the superficial blood-vessels, or the nerves.

The *diagnosis* of uncomplicated non-penetrating wounds of the thorax is generally easy. The history of the injury, together with the result of inspection, will enable the surgeon to determine the character of the wound. Hemorrhage, as a rule, is slight unless one of the larger blood-vessels is injured. In extensive division of muscular tissue there may be some resulting loss of voluntary motion, and if motor nerve-trunks are divided, as the posterior thoracic or the anterior thoracic branches of the brachial plexus, paralysis of the serratus or of the pectoral muscles may be noted.

It is often difficult to determine accurately whether a given wound of the thorax is limited to the external soft parts or has penetrated into the thoracic cavity and damaged one or more of the contained viscera. The reason of the difficulty lies in the fact that in the beginning, visceral injuries may present no symptoms or signs which positively point to a grave lesion. This is particularly the case in gunshot wounds of the lung.

The question as to whether a bullet may half encircle the chest (contour wounds), the track of the bullet lying wholly within the soft parts along a rib, or the external intercostal fascia, is one upon which considerable difference of opinion has been expressed. Some years ago I observed a case where, from a self-inflicted pistol wound, the point of entrance was about 1 inch to the left of the sternum in the fourth intercostal space. The bullet was subsequently found on a slightly higher level beneath the skin, just to the left of the spinal column. During the week the patient was under observation there was absolutely no sign of injury to the heart or lungs.

The *prognosis* in non-penetrating wounds of the thorax is generally favorable. While infection and extensive suppuration may follow lacerated wounds, especially if neglected, in most cases intelligent treatment will result in cure.

The *treatment* of superficial wounds of the chest is the same as in wounds elsewhere in the body. Thorough disinfection followed by suture and drainage is all that is required in the majority of instances. Gunshot wounds should not be too energetically explored unless there is a reason to believe that the bullet carried with it some foreign substance. Superficial disinfection and the application of a sterile dressing is all that is required in the majority of instances. Wounds of muscles should be repaired and the divided ends of severed motor nerves should be approximated at once with sutures.

Penetrating wounds of the thorax are much more important than

those which have just been considered; their importance depending upon the amount of trauma inflicted upon the intrathoracic structures. They arise from the same causes as the non-penetrating wounds, but in addition to these, compound fracture of the ribs and the sternum play an important rôle.

A small penetrating wound of the chest may open the pleural sac without further damage. If the amount of air which enters is small, no untoward symptoms may appear. If the wound in the pleura is larger and the opening is not immediately sealed by a falling together of the tissues when the injuring body is withdrawn, air enters the pleural cavity in large quantities and the lung is correspondingly compressed (pneumothorax). If, in addition to this, some important vessel is wounded, blood is aspirated into the pleural sac with each inspiration and the patient may collapse from concealed internal hemorrhage without any external sign (pneumohemothorax). Secondary infection may occur either from the wound or through the blood-current and give rise to empyema (pyothorax).

When, in addition to the wound in the pleura, the lung tissue is involved, practically the same results are produced with a slightly increased probability of infection, for the reason that the air pumped into the pleural cavity from the wounded lung furnishes an additional source of bacterial contamination. In this connection it should be stated that of the two sources of infection, the external wound is far more important, as subparietal ruptures of the lung, even when associated with hemorrhage, give a low percentage of pleural infections.

In severe lacerations of the lung there is a high grade of shock, both from the increased gravity of the local injury and from the more profuse hemorrhage which always results from extensive injury to these highly vascular organs.

Gunshot wounds constitute a large percentage of the penetrating wounds of the chest. Formerly, when the old-fashioned large-calibre low-velocity weapons were in use, the resulting injuries were much more severe than since the introduction of the modern high-velocity small-caliber arms. The reasons for this are the following: first, the larger projectile more commonly splintered the ribs and drove the fragments into the lung; second, the projectile less frequently passed through the chest, but more commonly remained imbedded in the lung or other tissues; third, the wounds produced by the more slowly moving bullets resulted in a greater amount of laceration of the lung tissue and consequently more hemorrhage. Experience furnished by the South African, the Spanish-American, and the Russo-Japanese wars has abundantly proved that a large proportion of the perforating wounds of the thorax made by the modern high-velocity rifles healed kindly and without suppurative complications. In general it may be stated that injuries occurring near the root of the lung are far more dangerous than those situated at a distance, near the periphery; that bullets which perforate the chest give rise to less disturbance than those which simply penetrate

and remain within its cavity; and that splintering of the bone always adds to the gravity of the injury. Gunshot wounds will be considered more at length in the chapter upon Military Surgery.

Injuries to the blood-vessels of the thoracic wall frequently complicate perforating wounds. Those most frequently wounded are the internal mammary and the intercostal arteries. Dangerous and even fatal hemorrhage may result from wounds of these vessels, and while blood appears, as a rule, in the external wound, the hemorrhage is, for the most part, within the chest. One reason why these hemorrhages are so dangerous is that by the movements of respiration blood is sucked from the open vessels into the pleural cavity, thereby preventing closure by nature's method of clotting.

Injury to the diaphragm is quite common in gunshot wounds of the chest. It is also observed in stab wounds and in compound fracture of the lower ribs. When the wound is large hernia of some of the abdominal viscera may occur into the thorax and peritonitis may develop from infection through the external wound.

Injuries to the thoracic duct may complicate penetrating wounds of the thorax. These are exceedingly rare except when associated with fracture of the spine and injury to other mediastinal structures, the symptoms of which, as a rule, overshadow those due to a wound of the duct. The immediate effect of an injury to the thoracic duct would be the extravasation of chyle into the mediastinal tissues or the pleura (chylothorax). Small wounds are said occasionally to close spontaneously. When there is a continuous leakage of chyle, however, inanition and rapid loss of weight result.

Penetrating wounds of the thorax associated with wounds of the *pericardium* or *heart* are always accompanied by severe shock; when the great vessels are involved death generally follows in a few moments. These injuries will be considered at length in Vol. V.

The **symptoms** of a penetrating wound of the chest depend upon the location of the trauma, the amount of force expended on the chest wall, and the character of the visceral injury. In some instances the amount of immediate shock is great, the patient will fall to the ground, become pale, and nauseated. The pulse will be small and rapid, the respiration shallow. In others, even when the amount of local and visceral injury is relatively greater, the patient will exhibit no symptoms or only a stinging sensation at the point of injury. When the lung is injured there will be cough and bloody expectoration in the majority of instances, with localized pain on respiration and the later development of pneumonia and emphysema. When air enters the pleural cavity there may be dyspnea. When severe bleeding occurs there is weakness, pallor, cold perspiration, air hunger, and extreme restlessness. Dyspnea following a penetrating wound of the chest may be due to injury to the pericardium or heart, to compression of the lung from pneumothorax or hemothorax, or simply to air hunger from hemorrhage. If the patient survives the immediate injury, infection may take place and result in empyema, abscess, or gangrene of the lung.

The **diagnosis** of a penetrating wound of the thorax is generally easy, although in certain rare instances it is exceedingly difficult. If none of the above symptoms are present physical examination of the chest will generally reveal the lesion by the presence of definite signs of a pleural exudate, lung inflammation, pneumothorax, or hemothorax. Where the pleura alone is involved there may be cough, sharp localized pain on inspiration, and later the development of a friction-sound over the point of injury. When air has entered the pleural cavity there will, in addition, be dyspnea, rapid respiration, the absence of normal respiratory signs, and hyperresonance on percussion. If the lung is wounded the cough will be more marked and accompanied often by a frothy, bloody expectoration. Occasionally air may be heard on auscultation, issuing from the wound in the lung. If bleeding has occurred, either from the parietal wound or from the injured lung, there will be flatness over the most dependent part of the chest with absence of fremitus and respiratory sounds. In all of these conditions subcutaneous emphysema may develop, either from the external wound or, in case of injury to the lung, it may appear first at the root of the neck.

The **prognosis** in penetrating wounds of the chest is always serious. When there is injury to the heart or great vessels death may occur in a few moments from the severity of the shock or from hemorrhage.

In severe crushing injuries associated with fracture of the spine or compound fracture of the ribs or sternum the outlook is always grave. The same is true in severe lacerations of the lung and in concealed hemorrhage, either from the injured lung or from one of the large vessels in the chest wall.

In the cases where the lung is involved the patient may recover from the immediate danger only to be again threatened by the danger of septic complications. The development of pleurisy with effusion, pneumonia, abscess of the lung, and empyema always adds to the danger of such injuries. The presence of pneumothorax does not necessarily add to the gravity of the case, provided the wound of entrance is quickly sealed, as air in the pleural cavity is, as a rule, soon absorbed. Blood in the pleural cavity absorbs more slowly, but if uninfected its presence does not necessarily introduce an element of grave danger. It is the common experience of surgeons that the presence of both blood and air in the pleural cavity from an external wound is far more apt to cause empyema than blood and air derived from a wound of the lung. The reason for this is probably due to the fact that the air in the smaller bronchi and air cells is generally sterile, while air entering the chest from an external wound is frequently contaminated.

The prognosis of gunshot wounds of the chest is relatively more favorable now than it was twenty years ago. This is due to the fact that the modern high-velocity projectile generally perforates the chest, produces less laceration, and its track is more often sterile. Unless the perforation is near the root of the lung and injures a large vessel, the wounds generally heal promptly if infection can be excluded. It is not uncommon to see patients who have been shot through the lung recover

completely in a week or ten days without experiencing discomfort of any kind.

In the **treatment** of a penetrating wound of the chest one must endeavor to combat the shock of injury, arrest hemorrhage, and prevent or control infection. The patient when in severe shock should be placed in bed with the head lowered, wrapped in warm blankets, and heat applied by means of hot-water bottles to the feet and extremities. Stimulants should be administered by the mouth, rectum, or hypodermically. Cough and restlessness should be controlled by morphin. An intravenous infusion of normal hot salt solution should be given where the symptoms of shock are progressive. If there is active bleeding from the internal mammary or intercostal vessels they should be exposed and ligated. Bleeding from a wounded lung can sometimes be controlled by inducing an artificial pneumothorax, which causes retraction of the lung and consequent closure of the bleeding parts.[1] In the presence of a progressively increasing hemothorax threatening life, the surgeon should freely open the pleural sac by resection of one or more ribs and attempt to arrest the hemorrhage by suture, ligature, or by packing.

In the absence of symptoms of grave shock or of hemorrhage, and if there is reason to believe that the wound is free from infection, the treatment should consist in careful disinfection of the wound area and the application of an aseptic dressing. Probing a penetrating wound of the chest is to be discouraged. It rarely gives much information and may introduce infection. Suture of the external wound is generally contra-indicated unless the laceration of the soft part is extensive, and then the wound should only be united in part, gauze drainage being inserted to allow the escape of the air and wound fluids. Absolute rest is to be insisted upon if there is danger of recurrent hemorrhage. Strapping of the chest or the application of a snug binder will give comfort and often diminish cough.

When embarrassed breathing is due to compression of the lung from the presence of air in the pleural cavity, this can often be withdrawn by aspiration. This operation may also be necessary on account of a secondary serous effusion or for the removal of fluid blood. When there is danger of active bleeding, however, it is best to delay the removal of air or fluid. The treatment of the secondary septic complications will be considered later.

In the treatment of penetrating wounds of the thorax involving the diaphragm, and in rupture of the diaphragm from thoracic or abdominal contusions, an effort must be made to suture the diaphragmatic opening.

In a recently published article by E. Wyllys Andrews, attention is called to the fact that the mortality following suture of the diaphragm by means of a transpleural operation is far less than that by the abdominal or combined method. In a recent case of stab wound involving the lung, diaphragm, and stomach, Andrews encountered considerable difficulty in suturing the diaphragmatic rent through the laparotomy

wound. He succeeded in closing the wound, however, by placing several transpleural sutures, introduced inward from the surface of the chest through the intercostal muscle and diaphragm into the peritoneal cavity, then outward through these same structures, entering on the opposite side of the diaphragmatic wound. When the sutures were tied the wounded portion of the diaphragm was brought tightly in contact with the parietal pleura lining the chest wall. This ingenious method is applicable to peripheral wounds of the diaphragm lying near the chest wall.

Under ordinary conditions the transpleural operation is performed by resection of one or more ribs, exposure of the diaphragmatic wound and the introduction of one or more rows of absorbable sutures. The question of drainage of the pleural sac must be determined by the amount of contamination present.

OSTEOMYELITIS OF THE RIBS AND STERNUM.

Acute septic osteomyelitis of the ribs and sternum is rare. In the ribs the disease is generally encountered in the anterior portion, often near the costochondral junction. The process begins by a focus of inflammation in the medullary portion of the bone, this extends in the direction of least resistance, which is along the central cancellous tissue, thrombosis of the vessels occurs which, by shutting off the blood-supply, results in necrosis. The pus finally reaches the surface and spreads beneath the periosteum, forming a subperiosteal abscess. This finally ruptures and the pus eventually finds its way to the surface and discharges through the skin. The periosteum surrounding the necrotic portion of the bone thickens and finally becomes calcified, forming an involucrum containing the imprisoned necrotic area or sequestrum.

The **symptoms** caused by this disease are at first severe localized pain over the inflamed point with fever and prostration. When the pus burrows beneath the periosteum the pain is lessened and a fusiform elastic tumor develops over the bone, with signs of inflammation of the skin. When the abscess ruptures a sinus is left leading to the sequestrum.

Typhoid osteomyelitis of the ribs is more frequent than the pure septic variety. The pathologic process is practically the same, but the course of the disease is slower and, as a rule, less painful. It is rarely accompanied by much fever, although the initial pain may be severe.

Tuberculous osteomyelitis of the ribs is more common than either of the former varieties. It affects by preference the costochondral junction, the cartilage, or the chondrosternal joint. Unlike tuberculosis of the spine and long bones, it frequently follows injury, and is more common in middle-aged adults than in children. It is often associated with pulmonary tuberculosis, glandular or other manifestations of the disease. The disease may begin in the medullary cavity of the bone or just beneath the periosteum; subperiosteal or subchondral abscesses occur either in front and eventually rupture on the surface, or

behind and burrow extensively between the pleura and the chest wall. Rupture into the pleural cavity, however, is rare.

The **symptoms** of tuberculous osteomyelitis of the chest wall are generally mild in character, there is little pain and no fever, or other signs of constitutional disturbance. Often the first sign of the disease to attract the notice of the patient is the presence of an oblong, soft, oval swelling without redness or other signs of inflammation. This frequently ruptures spontaneously or as a result of an accidental blow. There is then a discharge of a large amount of thin curdy pus leaving a sinus which leads to a carious worm-eaten bone lying in a cavity with thick infiltrated walls.

Syphilitic or **gummatous osteomyelitis** resembles the tuberculous form of the disease in that it pursues a slow and generally painless course and may result in the same destruction of bone. It more frequently begins in the periosteum as a gummatous infiltration, forming an elastic fusiform tumor. Its presence is associated with marked changes in the blood-vessels (endarteritis), which so diminish the blood-supply to the bone that necrosis occurs. The end-results are so similar to the tuberculous form of the disease that in many instances they cannot be distinguished clinically.

In the **treatment** of the disease one should seek to adopt measures in the early stages to limit the amount of bone destruction. In the septic variety early incision of a subperiosteal abscess may result in bettered circulation and a limitation of the necrosis to a small area. In the syphilitic variety the early exhibition of large doses of potassium iodid will often cause the gumma to disappear before necrosis occurs. In the tuberculous form little is to be expected in the way of prophylactic treatment, for, as a rule, the presence of the disease is not recognized until considerable damage has been wrought in the bone.

The radical surgical treatment in all varieties consists in freely exposing the disease and removal of *all* diseased bone. Nothing is to be gained in attempting to preserve the involucrum in the septic cases, as the space left by the removal of the sequestrum is quickly filled in by dense fibrous tissue. Insufficient removal of diseased bone in the typhoid form frequently necessitates a second or even a third operation. In addition to the removal of the bone in the tuberculous cases the cavity should be thoroughly cureted and packed with formalin or iodoform gauze. In the syphilitic cases antisyphilitic medication should be combined with the surgical procedures.

NEW GROWTHS OF THE CHEST WALL.

New growths of the thoracic wall are divided for convenience into those which arise from the soft parts and those which take their origin from the bony framework.

Tumors of the breast and of the spinal column will be considered in separate chapters.

Tumors of the Muscles and Fasciæ.—Lipomata occur with

considerable frequency in the soft tissues of the chest wall. They generally arise either from the subcutaneous fatty tissues or from the tissues between or beneath the muscles. Intramuscular lipomata are exceedingly rare.

Fatty tumors occur most commonly about the shoulders and in the space between the scapulæ. They are occasionally found beneath the pectoral muscles, particularly near the axilla, and, more rarely, beneath the mammary glands. They grow slowly, present a rounded or globular appearance, are generally lobulated, and may present one or more points of attachment to the skin. They vary considerably in size, some reaching several pounds in weight. Lipomata occasionally become pedunculated and appear as elongated teat-like excrescences.

The *diagnosis* of lipomata of the chest wall is generally easy. They rarely if ever give rise to pain, but occasionally cause inconvenience from their size and the deformity which they produce. The chief points in diagnosis are their slow growth, the absence of deep attachments, their mobility, their lobulated structure, their attachment to the skin, and their soft elastic consistence. In the subpectoral lipomata these features may be masked by the overlying muscle; the submammary variety push the breast forward and may be mistaken for simple hypertrophy of the breast.

The *prognosis* is favorable, as they rarely recur if completely removed.

The *treatment* is by operative removal; this is easily accomplished by exposing the tumor by an incision of the skin and enucleating the mass with the fingers, as they are encapsulated and are easily separated from the surrounding tissues. The hemorrhage is slight and the wounds, as a rule, heal kindly.

Fibromata and the Fibroneuromata.—Isolated fibromata of the chest wall are rare. Multiple fibromata are more common. The isolated tumors generally arise from the fascia or intermuscular septa and appear as hard oval masses; their deep attachment render mobility slight. They grow slowly and produce pain only when they press upon other sensitive tissues. The multiple fibromata, *fibroma molluscum*, arise from the sheaths of the nerves and may be exceedingly numerous. The disease is rarely limited to the chest wall, but may extend over the entire body. The nodules vary greatly in size and often give rise to large folds of redundant skin, which cause great disfigurement. Occasionally small fibroneuromata may give rise to severe pain when the growth occurs upon a superficial sensory nerve.

The *diagnosis* of multiple fibromata is generally easy from the characteristics mentioned above. In the case of isolated fibromata the diagnosis is often difficult. It is often impossible clinically to distinguish them from the fibrosarcomata; extreme slowness of growth is about the only characteristic feature.

The *treatment* of this disease should be by excision of the growth in both varieties. When confined to a limited area of the skin this is often successful. Where the disease is widespread this treatment is obviously impracticable.

Cysts of the chest wall are of fairly frequent occurrence. The sebaceous cyst or wen is the commonest. It may occur in any part of the skin of the thorax, but is found generally over the back and shoulders.

Dermoids occur only in the median line. In front their most frequent seat is over the upper part of the sternum near the junction of the manubrium and gladiolus; behind they are not infrequently found over the spinous processes of the dorsal vertebræ. When in this situation the underlying spinous process is often rudimentary. These cysts, as a rule, are small and give rise to no symptoms.

Echinococcus cysts of the chest wall are exceedingly rare. They arise generally from the muscles, although cases have been reported where they took their origin from the outer surface of the parietal pleura or the bony parts. They give rise to no discomfort until their size causes pressure or produces a noticeable deformity.

The *diagnosis* of sebaceous cysts and dermoids is not difficult. Their oval, rounded appearance, their soft, doughy consistence, and the central comedo of the wen will generally serve to distinguish them from other tumors.

The *treatment* of wens and dermoids is to be found in the chapters on the Skin and on Tumors. Echinococcus cysts should be widely removed when this is possible. When too large or when from their deep attachments this is not practicable, they should be partly removed, opened, and packed.

Hemangiomata and **lymphangiomata** may occur on the chest wall as in other situations in the body. The flat port-wine marks require, as a rule, no treatment. The cavernous hemangiomata are often congenital and show a strong tendency to increase in volume. Lymphangiomata are apt to arise from the lymphatics of the axilla and may form large tumors.

The *treatment* of these conditions should be by wide excision and primary suture of the wound after ligature of all bleeding vessels. Wyeth's method of treatment of cavernous hemangiomata by the injection of boiling water is to be recommended in suitable cases.

Sarcoma of the chest wall may rarely arise from the soft tissues. As its most frequent origin is from the bone or costal cartilages, it will be considered more in detail in the next section.

Tumor of the Sternum, Ribs, and Costal Cartilages.—Osteomata may occur in the chest wall, generally as an outgrowth from the ribs near their cartilaginous junctions. As a rule, they develop first as chondromata and subsequently ossify, forming bony tumors which grow very slowly and rarely give rise to symptoms calling for surgical intervention.

Chondromata of the sternum and ribs are comparatively infrequent. The commonest seat of the disease is the junction of the ribs with their costal cartilages. They may occur in other parts of the ribs and more rarely in the sternum. When in the latter situation the growth appears at the junction of the gladiolus with the manubrium or the ensiform. These tumors grow slowly and, as a rule, painlessly, until by their size

they press upon some intrathoracic structure and cause pain or interference with function.

Pure chondromata are encapsulated and are composed of hyaline cartilage. Those occurring on the chest wall are rarely homogeneous, but are generally the mixed variety—myxochondromata, chondrosarcomata, etc. Chondromata occurring in the bony framework of the thorax should always be regarded as having a potential malignancy, as a large proportion show a tendency to recur after removal, and the recurrences often exhibit the histologic evidences of sarcoma. For this reason their treatment should consist in radical removal and will be further considered under the treatment of Sarcoma.

Sarcoma of the bony thorax may develop from the sternum or ribs. According to Quénu and Longuet [2] it is the most frequent form of new growth in these structures. Primary sarcoma of the sternum may be pure (osteosarcoma) or mixed (chondrosarcoma or myxosarcoma); it has also been reported as a highly vascular pulsating growth resembling aneurysm. Secondary sarcoma of the sternum may develop as an extension of the disease from the mediastinal lymph nodes (lymphosarcoma); or from sarcoma originating from the remains of the thymus gland.

Sarcoma of the ribs may occur as a central growth expanding the rib or as a surface growth, generally at its junction with the costal cartilage. The rate of development varies considerably, but, as a rule, it is much more rapid than chondroma. As the growth advances several ribs may become involved and, as a rule, the growth is much more extensive than it appears on the surface. Secondary sarcoma of the ribs may occasionally be caused by an extension of a growth from the soft parts, the breast, or from the lung or pleura.

The *prognosis* in sarcoma of the chest wall is exceedingly grave, the tumor, as a rule, grows rapidly, and unless radically removed at an early period death generally results in a comparatively short time.

The *treatment* should be radical removal at the earliest possible moment. Removal of the sternum for sarcoma is a much more dangerous operation than for inflammatory disease. This is due to the fact that in the latter condition the mediastinal portion of the periosteum is greatly thickened and may be left protecting the important structures beneath, whereas in sarcoma the pleural cavities and the pericardium are generally wounded. Quénu and Longuet report 11 operations with a mortality of 48 per cent., and no known permanent cures. Keen, in 1897, reported 19 resections of the sternum, 9 of which were for sarcoma, with a mortality of 22 per cent.

Operations upon the ribs and costal cartilages are somewhat more favorable. In early cases the growth with the adjacent ribs and cartilages can occasionally be excised without opening the pleura. In most cases, however, it is wiser to make a complete excision of the chest wall, as the parietal pleura is so often involved in the process. According to Quénu and Longuet the mortality is about the same—26 per cent.—and the end-results are somewhat more favorable in the

penetrating operation. These authors also state that the nature of the growth, chondroma or sarcoma, makes little or no difference with the immediate mortality.

Primary carcinoma of the wall of the thorax occurs only as an epithelioma of the skin. The disease, as a rule, advances slowly and does not show any marked tendency to metastasis. It should be treated by radical excision.

Secondary carcinoma of the chest wall may arise from carcinoma of the breast, both by direct extension of the disease or through blood metastasis. In the former variety the disease may extend in the skin, *cancer en cuirasse,* or it may involve the muscles and bone. Secondary carcinoma of the sternum has been reported after excision of thyroid cancer. While favorable results have been achieved by extensive resection of the chest wall in early secondary carcinoma from direct extension from the breast, in the majority of instances of secondary disease operative interference is contra-indicated. In these cases the use of radium or other forms of radiant energy is to be recommended.

SURGICAL DISEASES OF THE PLEURA.

Pneumothorax is a condition characterized by the presence of air in the pleural cavity. Air may enter the pleural cavity through a penetrating wound of the thorax, it may escape from a perforation of the lung due either to trauma or disease, or it may occur as a result of a pleural infection from one of the gas-producing organisms. The presence of air in the pleural sac at once converts that potential cavity into an actual one. When sufficient air enters to cause the atmospheric pressure on the external surface of the lung to equal that within the air spaces, the lung collapses, ordinary respiratory efforts fail to produce adequate expansion, and its function is correspondingly impaired.

Aron's experiments[3] have shown that unilateral closed pneumothorax produces an increased blood-pressure, an increased intrapleural pressure on the opposite side, an increased rate and depth of respiration, which is compensatory and due to a diminished oxygenation of the blood. The disturbance, however, is generally slight as long as the other lung remains functionally intact and no unusual demand is made upon the respiratory apparatus. In open pneumothorax, however, where the pleural cavity communicates with the external air by means of an open wound of the chest wall or in the lung, the respiratory embarrassment is greatly increased. This is not due entirely to the collapsed and functionless lung on the affected side, but, as Murphy has demonstrated by animal experiments, to the absence of the piston action of the diaphragm which seriously embarrasses the function of the other lung, as these symptoms will frequently disappear as soon as the external wound is hermetically sealed, even though the amount of air in the pleura remains the same.[4]

When air has entered the pleural sac infection is likely to follow. It is more apt to follow an open external wound than a wound of the lung.

In pneumothorax due to spontaneous rupture of a tuberculous cavity a pleural exudate may follow which is serous, seropurulent, or purulent in character. This exudate is often of decided benefit to the patient, for by the increased pressure on the lung cicatrization of the wound is favored, and decided improvement in the tuberculous lesion has been known to follow in many instances.[5]

The **symptoms** of pneumothorax depend upon several factors. In traumatic cases, where a moderate amount of air enters the pleural space and where the wound is quickly sealed (closed pneumothorax), there is a moderate increase in the frequency and depth of respiration which is slightly more marked on exertion. If the wound remains open and air is drawn in and forced out with each respiratory effort, these symptoms are greatly increased, dyspnea is marked, cyanosis and extreme discomfort may be present. If in addition to an open pneumothorax there is disease or impaired function of the other lung, the respiratory embarrassment may become alarming and death from suffocation may occur.

The physical signs of pneumothorax are hyperresonance on percussion, absence of the normal respiratory sounds, voice transmission, and fremitus on auscultation.

Treatment is rarely necessary for this condition when unaccompanied by an external wound, unless urgent dyspnea is present, for, as a rule, a moderate amount of air in a closed uninfected pleural cavity will be absorbed. When dyspnea exists, relief occasionally may be obtained by aspiration of the chest.

Ehrmann, in a case of pneumothorax and progressive cutaneous emphysema from subparietal rupture of the lung, opened the chest and introduced a firm rubber drainage-tube, to the external extremity of which was attached a smaller, easily collapsible rubber tube. He then hermetically closed the wound in the thorax around the larger tube and found that air was expelled from the pleural cavity by expiratory effort, but during inspiration the soft-rubber tube collapsed and prevented the ingress of air. This ingenious device proved successful and the patient recovered.

When the pneumothorax is due to an open external wound through which air is drawn with each respiratory effort, the indications are completely to close the wound and thus restore the piston action of the diaphragm.

When there is reason to believe that the pleural cavity is uninfected the external wound should be thoroughly disinfected, closed by suture, and a sterile dressing applied. If the pleura is infected the wound may be closed by a firm gauze packing if urgent dyspnea exists, otherwise drainage should be established.

Spengler has pointed out that in tuberculous pneumothorax the presence of an exudate favors the healing of the pulmonary fistula.[6] He, therefore, advises expectant treatment until there is reason to believe that the wound has healed, then repeated aspirations, removing only a small amount of fluid at first to prevent violent cough, which

might reopen the wound. This plan of treatment is obviously only applicable when the exudate is sterile or tuberculous in character. Where septic infection exists drainage must be established.

Hydrothorax or an effusion of serum in the pleural sac, may arise from a variety of causes. It may result from mechanical obstruction to the circulation, as from uncompensated valvular disease of the heart, from pathologic conditions of the blood in renal or other diseases, from inflammatory diseases of the pleura or lung; from new growths, from trauma, or from the presence of blood or a foreign body in the pleura. Most of these conditions are of purely medical interest. Hydrothorax is, however, an important complication of certain surgical conditions, as wounds of the pleura and lung, subphrenic abscess, etc. It is particularly important in bilateral lesions of the thorax, where any increased interference with respiration may give rise to grave symptoms.

The fluid in hydrothorax is clear, straw-colored, or greenish-yellow, contains albumin, a few leukocytes, but, as a rule, no bacteria. In certain infectious processes in the lung or pleura a pleural exudate may be present which contains bacteria, but which is clear and otherwise resembles the sterile transudates. The difference between these exudates and the pus in empyema is only one of degree, the increased cloudiness and opacity of the latter being due to the presence of a greater number of leukocytes.

The presence of fluid in the pleural cavity diminishes the space normally occupied by the lung and forces the compressed organ to the upper, inner, and posterior portion of the cavity. In left-sided hydrothorax the heart is often displaced to the right and in extreme cases its apex-beat may be felt to the right of the sternum. In right-sided hydrothorax the apex-beat may be felt to the left of the normal point and above. These conditions naturally result in more or less severe interference with the respiration and heart's action. Frequent respiration, cough, and dyspnea are present when the amount of fluid is large. The physical signs of fluid in the chest are flatness to percussion over the area occupied by the exudate, absence of respiratory sounds, voice, and fremitus. In certain cases where the amount of fluid is large and the lung correspondingly compressed the respiratory and voice-sounds are transmitted and closely resemble the sign of consolidation. The use of the exploring needle is often necessary to establish the diagnosis in these doubtful cases.

The **treatment** of serous effusions in the pleural cavity is often successful by purely medical means. Diuretics, cathartics, and counter-irritation are to be recommended. Whenever a pleural exudate interferes with respiration or when after expectant or medical treatment it shows no tendency to absorb, it should be removed by aspiration. In certain cases, when the tendency of the fluid to reaccumulate is marked, repeated aspiration may be practised; other cases have been reported in which permanent drainage of the chest or thoracoplastic operations have been necessary.

Hemothorax, or the presence of blood in the pleural cavity, may result from the rupture of an aortic aneurysm or from trauma. In the traumatic cases, which alone interest the surgeon, it generally results from a wound of one of the larger vessels in the thoracic wall or from rupture or a wound in the lung. As this condition not infrequently occurs with but slight external signs of injury, the diagnosis must be made by the symptoms of concealed hemorrhage, pallor, weakness, a small rapid pulse, cold perspiration, air hunger, and restlessness, combined with signs of fluid in the chest already described.

The **treatment** should consist in absolute rest, the use of morphin or codein to prevent cough, a chest-binder to diminish the respiratory movements of the chest, and the external application of ice. Where the bleeding vessel is located in the chest wall, it should be exposed and ligated. Where there is reason to believe that the bleeding is from a wound in the lung, the admission of air to the pleural cavity, causing thereby an artificial pneumothorax with compression of the lung, may be tried in desperate cases where the condition of the patient will not warrant more exact measures. Whenever there is continued intrathoracic hemorrhage and the condition of the patient is such as to offer a reasonable hope of success, the chest should be freely opened by the resection of one or more ribs, the source of the hemorrhage accurately located, and the bleeding point secured by ligature, suture, cauterization, or gauze packing. In suture of a wound in the lung round needles should be employed and absorbable catgut used for sutures. There is abundant experimental proof to demonstrate that bleeding portions of the lung may be secured by large mass ligatures and returned to the pleural cavity. In addition to the above measures, elevation of the foot of the bed, saline infusions, stimulating enemata, and the hypodermic use of strychnin will be necessary when the loss of blood has been great.

Blood in the pleural cavity when uninfected will be absorbed. When infection occurs empyema results and should be treated by resection of a rib, removal of the infected clots, and drainage.

Chylothorax, or the presence of chyle in the thoracic cavity, results from injury to the thoracic duct. In the great majority of cases this is due to a fracture of the spine, although cases have been reported where the injury was due to destruction of the walls of the duct from suppurative or malignant disease. When the duct is wounded chyle is poured out into the tissues of the mediastinum or if the opening communicates with one of the pleural cavities into this sac. When the condition is a traumatic one the lesion is often overlooked for the reason that the causative force produces, as a rule, other and graver symptoms due to the associated injuries.

The **symptoms** of chylothorax are those of a gradual accumulation of fluid in the pleural cavity, associated with progressive loss of weight and strength. A positive diagnosis can only be made by the exploring needle. In this connection it must also be remembered that the fluid found in the chest in certain forms of malignant disease may often

resemble chyle, both in its milky appearance and in the fact that under the microscope fat-globules are demonstrated.

The **treatment** of chylothorax is unsatisfactory. If the wound in the duct is small, spontaneous closure may occur; when this does not take place the outlook is unfavorable, as radical treatment is impossible, operative repair being absolutely out of the question. Whenever the presence of chyle in the chest is demonstrated it should be removed by aspiration. Repeated aspirations have been followed by cure in a number of instances.

Pyothorax or Empyema.—This condition is characterized by the presence of pus in the pleural cavity. Purulent pleurisy may occur primarily as a result of a pyogenic infection of the pleura through an open wound or by means of infection conveyed to that membrane through the blood-current. It also occurs secondarily from infection reaching the pleura from a neighboring focus, as a pneumonia or abscess of the lung, from subphrenic suppuration, mediastinal disease, or from an infected focus in the chest wall. With the exception of empyema due to a penetrating wound, which is generally purulent from the beginning, most cases of empyema begin with an exudate of clear serum in the pleural cavity, which at a later period becomes purulent from an increase in the number of leukocytes. In a certain number of cases of pleurisy with a sterile serous exudate, infection is introduced by aspiration or through the blood-current from some remote septic focus. In the majority of instances, however, the pus-producing organisms are present from the beginning and give rise at first to a serous exudate poor in cells. The leukocytes increase in numbers as the process develops and the exudate gradually changes its appearance from a clear straw-colored fluid to one which is cloudy and, finally, opaque or creamy. The pus produced by a pneumococcus infection is generally thick and creamy, yellowish, or greenish in color; that produced by the streptococcus is thin, watery, and flaky. Foul-smelling pus is generally due to the colon bacillus or one or more of the putrefactive organisms. In tuberculous empyema the pus is thin and watery and contains masses of caseous material. In rare instances chronic empyema may be due to actinomycosis or to one of the streptothrix group of organisms.

In all cases of empyema the pleura is thickened and is covered by a more or less extensive fibrinous exudate. The pus often separates into two layers, the upper of relatively clear yellowish fluid, the lower of thick creamy pus. In certain instances the collection of pus does not occupy the entire pleural cavity, but is limited to one portion, where it is walled off by adhesions. Such localized empyemas are frequently found between the diaphragm and the base of the lung in cases where the infection is carried upward by the lymphatics from some abdominal focus. Interlobar empyemas are not infrequent in cases where the disease is secondary to pneumonia. As in other cases when fluid occupies the pleural cavity the lung is compressed and if the exudate is large the other thoracic organs are more or less displaced. An empyema may occasionally rupture spontaneously through an inter-

costal space, it may break into a bronchus, or it may burrow downward along the spine and follow the psoas muscle to the groin. A few cases of spontaneous cure have been reported.

The **symptoms** of empyema are, in general, those of a septic toxemia plus those of a pleural effusion and a compressed lung. In the beginning there may be symptoms of pleurisy or pneumonia, pain in the chest, shortness of breath, fever, etc., of some abdominal disease, as appendicitis, cholecystitis, or subphrenic abscess; or of some general infectious malady. Sooner or later there will be evidences of embarrassed respiration associated with the characteristic signs of pus. The respirations will be increased in frequency, will be short and often jerky; one side of the chest will show diminished mobility and the intercostal spaces may be obliterated or even bulging. There will be flatness to percussion over the area of fluid with absence of fremitus and voice transmission.

The fever will assume an irregular type with considerable variation between the morning and evening records. There may be chills and sweats with progressive loss of weight and strength. In the septic varieties the leukocyte count will be high, with a greatly increased percentage of polynuclear cells. In certain cases, if unrelieved, the infection may become generalized, with metastatic infection of the joints and other organs. Death from pyemia or from exhaustion from prolonged toxemia is the commonest termination in the neglected cases; it may also occur from nephritis, from excessive displacement of the heart, or from suffocation from flooding the lungs with pus as a result of a rupture into a bronchus.

The **diagnosis** of empyema is, as a rule, easy when all of the above-mentioned symptoms are present. It not infrequently happens, however, that the onset of the disease is very insidious and the presence of pus in the pleural cavity is often overlooked even by experienced observers. It must also be remembered that the presence of a large amount of fluid in the chest, especially in children, will frequently give the physical signs of consolidation of the lung (loud tubular respiration and transmission of voice).

Recently Pfeiffer has demonstrated that pleural effusions as well as intrathoracic tumors give rise to a characteristic deviation of the intrathoracic portion of the trachea to the opposite side, which is readily seen on an *x*-ray plate. The *x*-ray is also of value in demonstrating displacements of the heart and in differentiating between tumors and fluid accumulations. In all doubtful cases the diagnosis should be verified by the aspirating needle.

The **prognosis** in empyema depends upon several factors. In children the disease is generally the result of pneumococcus infection and is not, as a rule, accompanied by a high degree of toxemia. If recognized and treated early the outlook is favorable. The same is true in a pneumococcus empyema at a later period of life. Streptococcus and staphylococcus infections of the pleura, on the other hand, give rise to more virulent toxemia and are more apt to be followed by

a general blood infection. In these cases, therefore, the prognosis is less favorable, and if the pleural lesion occurs as a late complication of some other severe suppurative process the outlook is grave. In empyemas resulting from pulmonary abscess or gangrene or the rupture into the pleura of a subphrenic abscess, the prognosis will depend largely upon the character of the infection and the degree of toxemia and prostration which is already present as a result of the primary disease. In tuberculous empyemas the prognosis is unfavorable.

In the **treatment** of non-tuberculous empyema the only safe rule to follow is to open and drain the cavity as soon as the presence of pus is positively established. While cases are on record where an empyema has been spontaneously cured by rupture into a bronchus or through the chest wall, and in rare instances by encapsulation of a small purulent focus and the subsequent absorption of the fluid and calcification of the

Fig. 315.—Wilson's Empyema Drainage-tube.

cellular detritus, to delay operation in the hope of such a result is hazardous in the extreme. Unless the patient is actually moribund, operation should always be attempted, as it offers the only chance of recovery to the patient. Removal of the pus by aspiration has occasionally been successful in late cases of pneumococcus empyema after the fluid has presumably become sterile by the death of the organism. This treatment, however, is not to be recommended, as in the majority of instances it will have to be followed by more radical measures, and valuable time is lost by the delay. The operation of choice is thoracotomy with removal of a portion of one or more ribs, and the establishment of adequate drainage by the use of large drainage-tubes or by the use of Wilson's double-flanged empyema tube (Fig. 315). When the pus lies free in the pleural cavity the opening is best made in the midaxillary line about the eighth or ninth space: when the collection of pus is localized the opening should be made over the center of the

focus. In encapsulated empyemas between the diaphragm and base of the lung a low thoracotomy should be made and the lung separated from the diaphragm by the finger or some blunt instrument. In all empyemas it is advisable to aspirate before making the incision and not to open the cavity until the purulent focus is accurately localized. As soon as the cavity is opened and the drainage apparatus is secured in place, a large gauze and cotton dressing should be applied and snugly

FIG. 316.—WILSON'S EMPYEMA DRAINAGE-TUBE IN POSITION.

held by a chest-binder. It is rarely advisable to irrigate the cavity either at the time of operation or subsequently, unless the discharge is fetid or contains masses of necrotic material. In favorable cases removal of the pus is generally followed by an immediate improvement in the symptoms.

Bryant has recently advocated aspiration drainage of the chest in

empyema by means of a collapsible rubber bulb which he attaches to the outer extremity of a drainage-tube. The latter should reach to the bottom of the suppurating cavity, should accurately fit the opening in the chest wall, and near its attachment to the bulb should be fitted with a stop-cock, which permits the removal and emptying of the bulb without admitting air to the chest. The tube and bulb are strapped to the chest wall and covered by the usual dressings and binder.

Another and very important indication must, however, be met during the convalesence, and that is to adopt measures to bring about expansion of the lung. If the operation has been performed

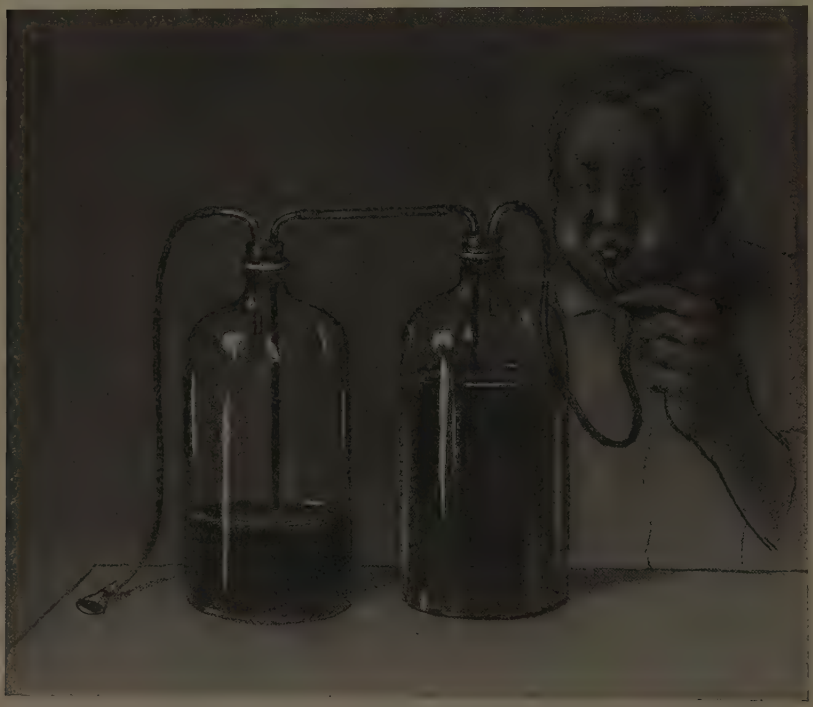

Fig. 317.—Wolff's Bottles.

at an early period in the disease, before the exudate on the visceral pleura of the collapsed lung has had time to organize, expansion may take place spontaneously as soon as the suppurative process is at an end. In the cases in which operation has been delayed, especially in adults and where expansion of the lung does not occur, it is advisable to have the patients increase the intratracheal pressure by blowing into one of two connected Wolff's bottles and thereby transfer a quart or more of the fluid from the first into the second bottle and back again (Fig. 317). If this is practised once or twice a day the lung will gradually expand and in favorable cases eventually fill the thoracic space. In young children the lung may be expanded by placing the wide end

of a glass funnel over the thoracic wound and by means of a rubber tube and aspirator exhaust the air from the pleural cavity (Fig. 318). During this maneuver the lung will often be drawn into the wound and care must be exercised not to wound it by too vigorous aspiration. The use of Bryant's aspiration drainage apparatus is particularly serviceable in bringing about expansion of the lung in the early stages of the disease.

FIG. 318.—ASPIRATOR AND GLASS FUNNEL.

When operation has been delayed and the collapsed lung is firmly held by a thick fibrinous exudate on its surface, Fowler and, later, Delorme advised freely opening the thoracic cavity by an osteoplastic flap and stripping the fibrinous exudate from the visceral pleura (decortication of the lung). This is sometimes followed by an immediate partial expansion of the lung, which will then go on to complete

recovery. Where the operation has been still further delayed and cirrhotic changes have occurred in the lung which prevent expansion by any of these methods, recovery is indefinitely delayed, owing to the presence of a suppurating cavity which cannot be obliterated. In these cases prolonged suppuration leads to chronic sepsis with progressive anemia and amyloid changes in the other organs. As the collapsed and cirrhotic lung cannot expand, measures must be instituted to approximate the chest wall to the lung. The chief obstacles to the accomplishment of this are the unyielding costal arches and the rigid thickened pleura.

Two operative procedures have been recommended for the relief of this condition. If the cavity is of comparatively limited extent, Estlander's operation, or the removal of several ribs, leaving the periosteum and the intercostal muscles, is indicated. This allows a collapse of the remaining soft tissues down upon the lung and thus obliterates the dead space. When the cavity is larger, Schede recommended complete removal of the ribs and intercostal muscles, leaving only a large flap consisting of the skin and superficial muscles, which is afterward sutured in place and made to lie in contact with the collapsed lung. The latter operation, though one of the severest procedures in surgery, is often followed by surprisingly satisfactory results (Fig. 321).

Lloyd has recently advocated a method of primary operation by which he believes that the permanently collapsed and cirrhotic condition of the lung can be avoided.

He makes a sufficiently large opening into the chest to enable him to introduce one or more fingers or the entire hand into the pleural cavity. After the pus has drained away the anesthetic is suspended and the entire lung separated from the chest wall by breaking down all adhesions. This manipulation causes the patient to cough violently, which by increasing the intratracheal pressure causes an immediate expansion of the lung. He reports over 200 cases treated by this method with a mortality of about 20 per cent.

The advisability of operating upon a tuberculous empyema is open to question. The pus in these cases, as in other cold abscesses, rarely gives rise to marked toxemia. As soon as the chest is opened, however, mixed infection is sure to occur, and as a result fever and chills, sweats, and a severe grade of septic intoxication is apt to follow. For this reason it is advisable to delay operation in these cases until spontaneous rupture is imminent and then to endeavor to prevent added infection of the cavity by scrupulous care in the dressings. Removal of the fluid by aspiration and the subsequent injection of an emulsion of iodoform has occasionally been followed by benefit.

New Growths of the Pleura.—Primary new growths of the pleura are exceedingly rare. Secondary tumors are of more frequent occurrence and may result from direct extension of a growth from the chest wall, mediastinum, or lung, or from metastasis from remote disease, in which case they are, as a rule, associated with similar growths in the lung. Of the primary tumors of the pleura all are of mesoblastic origin.

Endothelioma of the pleura occurs as a diffuse thickening of the membrane or in the form of numerous scattered nodules. It may or may not be associated with the presence of fluid. When fluid is present it is often blood-stained. The growth of these tumors is slow and the symptoms and signs are those of a pleural exudate. Pain is present in a certain number of cases and resembles the pain of dry pleurisy. In a case recently reported by Butler there was an irregular temperature. Leukocytosis is present and, according to Cabot, may be so high as to suggest a suppurative lesion. The disease has been observed more frequently in the left side. When the growth is extensive, respiratory symptoms may be produced by compression of the lung.

The *diagnosis* is generally established by introducing a needle, and after withdrawal of the fluid finding the physical signs unchanged. The sensation imparted to the hand by thrusting the needle through solid resisting tissue will also serve to confirm the diagnosis.

Sarcoma of the pleura has been reported as a primary growth in a number of instances. Like endothelioma it occurs most frequently on the left side. Unlike endothelioma the growth is more rapid and is more often associated with the presence of bloody fluid in the cavity. The *symptoms* of sarcoma of the pleura are the rapid and unexplained formation of fluid, together with an afebrile progressive dyspnea. The physical signs are the same as those of endothelioma, as the disease may occur as a single large growth or as numerous smaller nodules.

The *diagnosis* can often be established, according to Warthin, by the finding of atypic cells with mitotic figures in the fluid withdrawn by aspiration. The *x*-rays will occasionally be of value in the diagnosis of tumors of the pleura, although it is generally impossible by this means to distinguish between pleural growths and those occurring in the lung.

Secondary carcinoma and **sarcoma of the pleura** are of more frequent occurrence and present practically the same symptoms and signs as the primary growths.

The *treatment* of these conditions is unsatisfactory, with the exception of the early and limited secondary growths arising from extension from the chest wall, which have been considered earlier in the chapter. Removal of fluid is indicated when dyspnea is present. Radium and the Röntgen rays may be given a trial with a view to temporary relief.

SURGICAL DISEASES OF THE LUNG.

Abscess of the lung is a comparatively rare disease. It frequently follows pneumonia, both of the lobar and lobular type, although it is said to occur more often after the latter. It also occurs as a result of the aspiration of a foreign body into the bronchus, from infection of a hemorrhagic infarct, from the rupture into the lung of a neighboring septic focus, from a penetrating wound, from infection carried by the blood-current, and from malignant growths. The most frequent microörganisms present in abscess of the lung are the pneumococcus, the streptococcus, and the staphylococcus. Mixed infection is common.

According to Tuffier's statistics, pulmonary abscess occurs more frequently in the lower lobe, and, as a rule, nearer the posterior than the anterior surface. In the majority of instances a single abscess is present; more rarely the disease is multiple and bilateral.

The **symptoms** of pulmonary abscess are, as a rule, fairly characteristic, especially if the lesion follows a pneumonia. If during the course of a pneumonia the time for defervescence arrives, and instead of the usual drop in temperature and subsidence of the other acute symptoms there occurs increased fever, chills, and sweats without a notable increase in the area of consolidation, abscess should be suspected. If the fever assumes an irregular type, with marked morning remissions and if there occur marked prostration and wasting, the probabilities of abscess are increased. If, in addition, the patient suddenly expectorates a large amount of pus having a disagreeable, foul, penetrating odor, and on examining the chest signs of a cavity are present, the diagnosis is established.

Where rupture of the abscess into a bronchus is delayed the physical signs are those of consolidation in the early stages, with diminished fremitus, respiratory sounds, and voice transmission when the amount of pus is large. After rupture into a bronchus the signs of a cavity appear, with coarse, moist, bubbling râles and amphoric breathing. It is a well-known fact that the physical signs of pulmonary abscess are frequently misleading when accurate localization is desired, the signs pointing to an area too high when above the hilum, and too low when below that point. Murphy questions the accuracy of this observation and states that in his experience the physical signs furnish reliable data when the lesion is near the surface. All observers agree that in centrally located lesions the physical signs are often insufficient accurately to localize the focus.

When doubt exists the *x*-rays will often be of the greatest service, and in my experience furnish the most valuable diagnostic data. Exploratory puncture with the aspirating needle is to be recommended provided the surgeon is prepared to operate if pus is reached. Numerous instances are on record, however, where pleural infection, gangrene, and cellulitis have followed the use of the needle without subsequent drainage.

The **treatment** of abscess of the lung should be the same as for abscess in any other tissue. Free incision and drainage at the earliest possible moment give the best result. While a fair proportion of the cases recover spontaneously after rupture has taken place into a bronchus, the delay often results in strong adhesions of the lung to the chest wall, which prevent collapse of the cavity after it is emptied. The reparative process in these cases is exceedingly slow and many months or years of invalidism may follow. As soon as the diagnosis is established, therefore, and the focus is accurately localized, an opening should be made in the chest wall by the resection of one or more ribs. If the lung is adherent to the parietal pleura a needle or probe director should be thrust into the center of the indurated mass, and as soon as the pus is reached the small opening should be dilated with dressing-forceps or the

finger, and adequate drainage provided by means of tubes or gauze packing. If there are no adhesions between the parietal and visceral layers and the pleural cavity is free from infection, an attempt should be made to create adhesions before opening the abscess. This is best accomplished by a method successfully used by Keen: A rectangular flap is made by one incision 5 to 6 cm. long in the axis of one rib and two short incisions at each end. This exposes one or—if the latter incisions are made sufficiently long—two intercostal spaces. By light touches of the knife the intercostal muscles are gradually divided and pushed up and down until the parietal pleura is reached. With care this can easily be done without wounding the pleura. If there are no adhesions the mottled surface of the lung can be seen moving up and down with each respiration. If adhesions exist the pleura is opaque and no such motion is seen. In order to produce adhesions it is only necessary to pack the wound for three or four days with iodoform gauze and stitch the flap in place by a few temporary sutures. The abscess can then be opened without danger of infecting the pleura.

The propriety of establishing external drainage in abscesses which have ruptured into a bronchus is open to question. The delay in healing in these cases is usually due to adhesions, which prevent collapse of the lung and cicatrization of the cavity. Under these conditions, Murphy advises thoracotomy and separation of the pleural adhesions or, where no adhesions are present, the production of an artificial pneumothorax by the introduction into the pleural cavity of sterile nitrogen gas. From the foregoing statements it is evident that accurately to determine whether adhesions of the lung to the chest wall exist or not is of the utmost importance in planning an operation for lung abscess. Murphy's method of determining this point is simple and reliable: A hypodermic needle is introduced over the supposed site of the abscess and when the point is imbedded in the intercostal muscle a rubber tube is attached which connects with a reservoir of sterile nitrogen gas; the needle is then pushed slowly inward. When the needle enters the pleural cavity the gas will pass rapidly through it and produce an artificial pneumothorax. If adhesions exist no gas will escape through the needle. The presence of a localized area of cutaneous edema over a supposed lung abscess also indicates the presence of adhesions.

The **prognosis** after operation is generally favorable if the abscess can be drained without infection of the pleural cavity. When complicated by empyema the outlook is more serious. The cases which follow lobar pneumonia are more favorable as a class than those due to other septic processes. In general it may be said that under surgical treatment from 60 to 75 per cent. of the cases recover.

Gangrene of the lung may arise from the same causes as abscess, but, as a rule, it occurs in greatly debilitated subjects and is often associated with diabetes, alcoholism, or nephritis. Pneumonia is undoubtedly the most frequent predisposing factor, from 3 to 10 per cent. of the deaths in this disease being due to gangrene.[7] Embolism of a branch of the pulmonary artery and hemorrhagic infarction precede

the disease in some instances, and the extension of a putrefactive process from an ulcerative fetid bronchiectasis may more rarely give rise to the condition.[8] The lesion consists in a more or less extensive area of necrosis of the lung tissue which has undergone putrefaction as a result of infection by one or more of the putrefactive microörganisms. The mass appears as a collapsed, dark-colored grayish or greenish slough, which may be separated from the living lung tissue by a distinct line of demarcation. According to the statistics of Tuffier, the disease is found with greatest frequency in the lower segment of the lung. In some cases the process is widely diffused and may involve an entire lung.

The **symptoms** of pulmonary gangrene are usually preceded by those of pneumonia or some other predisposing condition. The first and most characteristic sign of the disease is the presence of a horrible sickening fetor of the breath. There is, as a rule, cough and abundant expectoration of an exceedingly foul-smelling material, which if allowed to stand in an examining glass will usually settle into three layers, the upper of dark frothy mucus, the middle of comparatively clear fluid, the lower of thick gangrenous detritus. Masses of necrotic lung tissue are occasionally expectorated and the presence of elastic fiber can generally be demonstrated by the microscope. There is always some fever, although it is not, as a rule, high, and may be subnormal; the pulse is weak and accelerated and the respirations rapid and shallow. The most characteristic sign of the disease is the extreme prostration, which is often wholly out of proportion to the other symptoms. Hemorrhage may occur in the course of a pulmonary gangrene from erosion of one or more vessels. The amount of blood expectorated varies with the size of the vessel eroded. Blood-stained or prune-juice expectoration is not infrequent. Severe hemoptysis may occur and, rarely, be the immediate cause of death.

The **diagnosis** of gangrene of the lung is, as a rule, easily established when the above-mentioned symptoms and signs are present. Accurately to determine, however, whether the process is circumscribed or diffuse, whether there are one or more foci, and if one focus, in what position in the lung it is located, is often difficult and occasionally impossible. Physical signs of consolidation occur early, those of a cavity at a later stage of the disease. Many authors have called attention to the fact that if one relies only upon physical signs to determine the precise location of the lesion, mistakes will often occur, the lesion being located too far downward when situated below the hilum, and too far upward when situated above that point. The *x*-rays will occasionally furnish valuable data as to the number and location of the lesions, and if the results are positive they should be relied upon rather than those obtained by auscultation and percussion.

Until 1881 the **treatment** of pulmonary gangrene was purely medical. This plan was followed by a death-rate of about 80 per cent. Bull, of Copenhagen, in 1881 successfully operated for gangrene of the lung in a woman twenty-three years of age, and strongly advocated surgical

intervention as the only rational treatment where the focus was at all extensive.[9]

Since surgical intervention has been carried out the results have been more favorable, the mortality falling to about 30 per cent. Operative treatment is contra-indicated in diffuse gangrene, bilateral or multiple areas of gangrene, and in those cases in which metastatic lesions can be demonstrated. In the circumscribed form the treatment should be surgical and consists in exposing the lesion by a resection of one or several ribs opening into the gangrenous area and establishing adequate drainage. The greatest care should be exercised to avoid infection of the pleura. If the affected area is not adherent to the parietal pleura measures should be taken to bring about this adhesion before the focus is opened. This is best accomplished by suturing the parietal to the visceral layer of the pleura by means of a round curved needle with plain catgut, after first placing a gauze pad over the external surface of the parietal pleura, the sutures passing through the gauze pad and both layers of the pleura. When this plan is followed the sutures rarely cut out and the subsequent incision may be made through the gauze pad. Unless the necrotic area has separated from the normal lung tissue no attempt should be made to remove it on account of the danger of hemorrhage. The softened area should be packed with gauze and the external wound kept widely open until the slough separates.

Tier strongly advises against the use of rubber tubes, which he believes frequently cause erosions of the blood-vessels.[10] When the slough separates it should be removed, the cavity packed with sterile gauze, and allowed to heal by granulation.

Bronchiectasis associated with a putrid bronchitis may give rise to a condition closely resembling abscess or gangrene of the lung. Dilatation of a bronchus may result in a fusiform, cylindric, or saccular cavity. The condition is generally due to prolonged ill health associated with chronic cough. When a saccular dilatation of a bronchus occurs, the secretions are retained and often become infected with putrefactive organisms. When the cavity becomes filled with this secretion a small amount will escape into the more sensitive neighboring bronchi and provoke a paroxysm of coughing. This, as a rule, slowly empties the cavity and the patient then remains quiescent until the cavity refills and is again emptied. The health is gradually impaired as a result of septic absorption and the loss of appetite, which in sensitive individuals arises from the putrid character of the expectoration. While fusiform dilatations of the bronchi are usually bilateral and are often present in cases of chronic bronchitis, the saccular variety is rare, as a rule, unilateral, and often single. This variety alone gives rise to surgical indications.

The **symptoms** of a sacculated bronchiectasis are the presence of a chronic cough occurring in paroxysms and associated with a profuse expectoration of an exceedingly foul-smelling pus. These paroxysms occur with considerable regularity, generally in the morning shortly after rising. The amount of secretion expelled at each paroxysm may

be very great. The odor is often so disgustingly foul as to permeate an entire apartment or ward and render it unfit for occupancy by others. Vomiting not infrequently accompanies these attacks of coughing. There is generally some fever, with gradual loss of weight and strength. On physical examination there are present the usual signs of chronic bronchitis, with loud moist râles over the lesion. After a paroxysm of coughing the signs of a cavity may be made out by auscultation and percussion. The *x*-ray will sometimes give shadows indicating the location of the focus, although they do not enable the examiner to differentiate between bronchiectasis, abscess of the lung, or a cavity due to tuberculosis. As in other suppurating lesions of the lung tissue, the use of an exploring needle for purposes of diagnosis is contra-indicated unless one is prepared to follow the exploration by immediate operation.

The **prognosis** in these conditions, if untreated, is not necessarily fatal, although death from exhaustion, chronic sepsis, and inanition is not infrequent. The conditions of life with fetid bronchitis and bronchiectasis are, however, burdensome and in sensitive individuals almost unbearable. These patients will often demand operative treatment if the surgeon can hold out even a small measure of hope of permanent relief. In estimating the chances of improvement by operation one must bear in mind that in the majority of instances the disease is multiple and bilateral, and that little or no relief can be expected in these cases as a result of surgical treatment. If the symptoms are characteristic of a sacculated dilatation and there is reason to believe there is but a single cavity, the prognosis for ultimate recovery is favorable. Operations are occasionally successful where two or more dilatations have been drained, although the operative risk in these cases is greater. The mortality following pneumotomy in these cases is relatively high, the statistics of Murphy and Hofmokl showing the death-rate to be somewhat over 50 per cent.,[11] although more recent reports by Gluck, Eisendrath, and others show improved results.[12]

In the **treatment** of this disease internal medication, local measures, such as sprays, inhalations, and intratracheal injections, should be given a fair trial before surgery should be considered. If these fail and the condition of the patient justifies the risk, practically all authorities agree that in cases of sacculated bronchiectasis with a narrow opening into the bronchus the cavity should be freely opened and drained through the chest wall.

The *technic* of this operation is the same as that for abscess of the lung. The focus should be accurately located and if adhesions are present the opening should be made through these direct to the cavity without opening the free pleural space. If adhesions are not present, the thoracic cavity should be freely opened by the resection of one or more ribs, the hand introduced, and the lung palpated accurately to locate the lesion. When this is found the lung should be drawn to the surface and firmly held while the cavity is opened with a scalpel, evacuated, disinfected, and packed with gauze. A counteropening for

drainage should be made in the most dependent portion of the pleural cavity. Murphy strongly advises this method for all pulmonary abscesses requiring external drainage, for the reason that collapse of the lung favors contraction of the cavity and rapid cicatrization. Where the opening into the bronchus is large, insuring free drainage of the cavity, the production of an artificial pneumothorax by the introduction of sterile nitrogen gas, as advised by Murphy, constitutes the best treatment.

Actinomycosis of the Lung.—Actinomycosis is an exceedingly rare disease in this country. In the great majority of instances the primary focus of the disease occurs in the mouth or in the digestive tract. In a certain number of cases, however, the ray fungus is inhaled and develops a primary focus in the lung. Secondary infection of the lung is of more frequent occurrence, generally by an ascending process from some abdominal focus.

The inflammatory process occasioned in the lung by the ray fungus resembles tuberculosis, in that it develops slowly without marked systemic reaction at first, tends to infiltrate all the tissues, and at a later period to form cavities. There is, however, a greater development of granulation tissue, which by subsequent contraction often gives rise to irregularities in the contour of the chest. When the process involves the pleural surfaces dense adhesions form, through which the disease gradually extends to the chest wall and subcutaneous tissues, to the structures of the mediastinum, or through the diaphragm to the abdominal viscera.

Pleural effusions may be present in the earlier stages and empyema not infrequently develops at a later period. These collections of fluid are, as a rule, limited in extent, owing to the presence of numerous adhesions.

The **symptoms** of actinomycosis of the lung are pain, cough, hemoptysis, fever, and loss of weight and strength. The sputum is scanty at first and mucopurulent in character. When an abscess ruptures into a bronchus it is more abundant and resembles in appearance the sputum of tuberculosis. It differs from this, however, in the absence of the tubercle bacilli and of elastic fibers. The diagnosis in the earlier stages can only be established by finding the ray fungus in the sputum. In the later stages of the disease, when the process involves the chest wall, the presence of more or less extensive areas of brawny induration of the skin with retraction of the thorax is characteristic of the disease. The physical signs of consolidation, with cavities or fluid, and the absence of tubercle bacilli and of elastic fibers in the sputum, would, according to Riedinger, justify the diagnosis of actinomycosis without the demonstration of the organism.

The ideal **treatment** of primary actinomycosis of the lung would be by thoracotomy and complete removal of the focus if that could be accomplished. The difficulty of early diagnosis, however, would render an opportunity for this method of treatment exceedingly rare. The removal of fluid from the pleural cavity, the opening and draining of

pus-cavities, and the exhibition of iodid of potassium or of the copper salts would be indicated in the more advanced stages of the disease.

The Surgical Treatment of Tuberculosis of the Lung.—Surgeons have long entertained the hope that early pulmonary tuberculosis could be cured by radical removal of the primary focus. This hope was markedly encouraged by the successful pneumectomies of Tuffier, Lowson, and Ferguson.

The procedure is certainly a rational one, but few patients can be found who will give consent to so radical a procedure at a time when their discomfort is so slight. Moreover, the mortality of pneumectomy is undoubtedly as high or higher than that of incipient tuberculosis treated by modern non-operative methods. These facts, together with the difficulty which is often experienced in accurately locating a small primary focus and in being sure that no other focus exists, have resulted in comparatively few attempts at early radical removal. DeForest Willard in 1902 reported 6 cases with only 4 recoveries. It is highly probable that a number of fatal cases have not been reported, which would materially raise the mortality percentage.

Ever since the historic case of cure of a tuberculous cavity by an accidental sword thrust in a duel, reported by Bligney in 1670, surgeons have sought to relieve these patients by deliberately applying the same method. While in a large number of cases tuberculous cavities have been opened and drained through the chest wall with operative recoveries, the number finally cured or markedly relieved by this procedure is exceedingly small, so small, in fact, as to cause the majority of modern surgeons to condemn the operation.

It has been pointed out that these cavities, and especially those situated in the apex, drain better into the bronchial tubes than through an artificial opening. The reason why they do not heal under favorable hygienic surroundings is that, owing to the unyielding character of the thoracic wall, the surrounding lung tissue cannot collapse and obliterate the cavity. Measures to bring about this collapse of the cavity have been advised and successfully carried out by a number of surgeons. Landerer, Garrè, Quincke, and others have advocated removal of the ribs over a tuberculous focus to allow collapse of the soft tissues and final obliteration of the cavity. Others have suggested a limited rib resection and the production of an extrapleural pneumothorax by stripping the parietal pleura from the chest wall. Murphy, in 1898, strongly recommended the production of an artificial pneumothorax by the injection into the pleura of sterile nitrogen gas, which in the absence of adhesions would result in shrinkage of any cavity as well as to render the lung functionally quiescent; both being conditions which would favor nature's process of repair. These methods have been followed by encouraging results and, as the mortality is low, will undoubtedly soon yield abundant data upon which reliable conclusions can be based. At the present time the consensus of surgical opinion seems to be that pneumectomy for the cure of incipient tuberculosis, although a perfectly rational procedure, is not to be recommended on account of its high

mortality, and the fact that one can rarely be sure that the area removed includes all of the disease; that the opening and draining of a tuberculous cavity with a view to a cure of the disease has little to recommend it, but that in cases where a high degree of toxemia results from a mixed infection in a tuberculous cavity, these symptoms may often be relieved by drainage; and that measures undertaken to promote collapse of a tuberculous cavity and functional rest of the lung are to be recommended in cases which are not improving under ordinary hygienic treatment.

New Growths of the Lung.—Benign tumors of the lung are, as a rule, of mesoblastic origin. Fibromata, lipomata, chondromata, and cysts have been reported. Benign solid tumors rarely develop to such a size as to cause symptoms and are of no surgical importance. Endotheliomata developing in the pleura may involve the lung secondarily and have already been considered.

Echinococcus Cysts of the Lung.—With the exception of the liver, hydatid cysts occur more frequently in the lung than in any other organ. The disease, however, is exceedingly rare in the United States. The fact that the disease occurs most commonly in the lower lobe of the right lung would lead to the belief that it is not infrequently secondary to echinococcus of the liver. The cyst by its gradual enlargement compresses the lung and may displace the heart and other mediastinal structures. Bulging of the chest wall and displacement of the abdominal organs occur at a later stage. Rupture occasionally takes place into a bronchus or into the pleural cavity. Infection of the cyst contents may occur.

The *symptoms* of an echinococcus cyst of the lung are those of pressure only in the earlier stages of the malady. Dyspnea on exertion with the later development of an afebrile cough and bloody expectoration and the physical signs of an intrathoracic tumor, would render the diagnosis probable. The finding of hooklets in the fluid obtained by aspiration or through rupture would remove all doubt.

The *prognosis* of the disease, if untreated, is grave. Death not infrequently results from rupture of the cyst into a bronchus or from septic infection.

The *treatment* of an hydatid cyst of the lung should be by marsupialization, stitching the cyst wall to the external wound for the purpose of continuous drainage. In some instances it may be possible to remove the inner or secreting layer of the sac. The result of operative treatment has been much more favorable than by the expectant plan. Aspiration in these cases, as in echinococcus of the abdominal organs, is to be condemned on account of the danger of infecting the pleura.

Malignant tumors of the lung occur both as primary and secondary growths. Primary carcinoma was found by Lenhartz 12 times in 2956 autopsies. It develops from the epithelium of the bronchial mucous membrane, the mucous glands, or from the alveoli. It occurs in both the slow-growing fibrous form and in the more rapid cellular variety. Primary sarcoma is much rarer than carcinoma. It occurs most frequently in the form of lymphosarcoma, which grows along the bronchial

tube and infiltrates large areas of the lung or in the form of spindle-cell sarcoma, which remains confined to one locality. Secondary carcinomata and sarcomata are much more frequently observed than the primary growths. As a rule, they are bilateral and multiple.

The *diagnosis* of secondary malignant growths of the lung is comparatively easy. The history of the primary focus, followed at a later period by cough, dyspnea, and the signs of bilateral consolidation and fluid in the chest, is generally sufficient, in the absence of fever and other signs of an acute or chronic inflammatory process, to establish the diagnosis.

With primary malignant growths the diagnosis is more obscure. The presence of an afebrile cough in a person of the cancer age, without rales, but with rapidly increasing signs of consolidation, should awaken the suspicion of carcinoma of the lung. The later occurrence of bloody or prune-juice expectoration, the development of hydrothorax, cachexia, and enlargement of the lymph-nodes at the root of the neck, with dyspnea and wasting, add to the probability of cancer, which may later be confirmed by the expectoration of a fragment of the tumor. The same symptoms and signs are present in sarcoma, which, however, may occur at any age, but is commonest before middle life.

The physical signs of a new growth of the lung are at first those of consolidation, with the subsequent development of fluid in the chest. At a later period the chest may be bulged and the intercostal spaces obliterated. Malignant tumors, especially the denser varieties, may often be detected by the Röntgen rays.

The *treatment* of malignant growths of the lung has, up to the present time, been simply palliative. If a sufficiently early diagnosis could be made pneumectomy would be indicated.

SURGICAL DISEASES OF THE MEDIASTINUM.

Injuries to the structures contained in the mediastinal space are exceedingly rare. They may occur from crushing accidents, gunshot and stab wounds, or as a result of fractures of the spine or sternum. The pericardium, heart, and great vessels are the organs most frequently involved in these injuries. The reader is referred to the chapter on the Surgery of the Vascular System for their consideration.

Hemorrhage into the mediastinum when not due to wounds of the heart or great vessels is seldom of large extent. The blood readily distributes itself throughout the cellular tissue and rarely gives rise to serious pressure symptoms. If uninfected it is rapidly absorbed. *Injury to the thoracic portion of the trachea* or to one of the bronchi gives rise to *emphysema* which fills the cellular tissues of the mediastinum and eventually appears at the root of the neck. From this point it may spread extensively throughout the subcutaneous tissue of the body. In mediastinal emphysema the normal cardiac flatness may be absent, and on auscultation a fine crackling sound may be heard synchronous with the heart pulsations. Death from suffocation may result from

complete rupture of the trachea or from hemorrhage into the air tube. The treatment of such injuries can, of necessity, be only palliative.

Inflammation of the structures of the mediastinum may be either acute or chronic. The acute form of mediastinitis may be due to trauma and subsequent infection through an external wound, to a wound of the esophagus or air tube, to the extension of an inflammatory process from the lung, pleura, ribs, sternum, or the cellular tissue of the neck. One of the commonest forms is the continuation downward of a deep cellulitis of the neck. Foreign bodies in the trachea, larger bronchi, or esophagus occasionally give rise to ulceration, which perforates these structures and causes mediastinal abscess.

Acute cellulitis or abscess of the mediastinum generally occupies the anterior portion of the space. Hare, in an analysis of 36 cases of acute mediastinitis, found that 30 were limited to this region. Chronic inflammation of the mediastinum is generally due to caries of the vertebræ, tuberculosis of the lymph-nodes, or to a tuberculosis of the ribs or the sternum.

The **symptoms** of acute mediastinitis are localized pain, fever, general body weakness, and loss of weight. The pain is deep-seated, often severe, and radiating. It is increased by movements, especially by raising the arms or bending the body backward. Tenderness is generally present over the sternum and the location of this tenderness may sometimes serve to establish the location of the abscess. The fever is variable, depending upon the extent of the process or the virulence of the infecting organism. Leukocytosis is present in the non-tuberculous cases.

In mediastinal abscess there may be chills and sweats. In certain cases the pus may burrow to the surface of the body and point at the root of the neck between the costal cartilages or in the epigastrium near the ensiform cartilage. In the chronic forms of mediastinitis the pain may be severe, but the constitutional symptoms are, as a rule, absent or comparatively slight in degree.

The **prognosis** in the acute septic forms of mediastinal inflammation is always grave; the danger being from sepsis or the rupture of an abscess into the trachea, which occasionally results in suffocation. In the chronic forms the prognosis is more favorable.

The **treatment** of acute mediastinitis should be by rest, cold to the chest, and measures to improve the patient's resistance. When signs of suffocation are present and there is reason to believe that the suppurative process involves the anterior mediastinum, the sternum should be trephined, the opening carefully enlarged by rongeur forceps, and the tissues carefully palpated or explored by the aspirating needle. When pus is found the opening should be sufficiently enlarged by the introduction of a closed dressing-forceps and withdrawing them partly opened. Drainage by rubber tubes or gauze packing should be established and the wound dressed with sterile gauze. If an abscess points externally the primary opening should be made in that location, even if a counter-opening has to be made later through the bone.

Surgical access to the posterior mediastinum is difficult. A posterior incision should be made, exposing the transverse process of one or more vertebræ; these with the adjacent portions of the ribs should be removed, and the posterior space entered by blunt dissection.

New growths of the mediastinum are rare. The statistics furnished by Hare's prize essay on "Mediastinal Diseases" show that carcinoma is the commonest; next in frequency comes sarcoma. The benign tumors are relatively infrequent, the proportion to malignant being as 1 to 4. Of the benign tumors lymphomata and dermoids are the most common, although fibromata, chondromata, lipomata, and echinococcus cysts have been reported.

The benign solid tumors rarely reach a large size and seldom give rise to surgical indications. Dermoids and hydatid cysts, however, not infrequently require operative treatment. Of the malignant tumors primary carcinoma arises most frequently from the tracheal or esophageal mucous membrane or from the remains of the thymus gland. Primary sarcoma occurs most commonly in the form of lymphosarcoma and is exceedingly malignant. Secondary carcinoma is more frequently observed than secondary sarcoma.

The **symptoms** of a new growth of the mediastinum depend somewhat upon the character of the tumor and the rapidity of its growth. Benign neoplasms frequently give rise to no symptoms, for the reason that by their gradual increase in size the other structures have an opportunity of adapting themselves to the pressure. Malignant growths, on the contrary, early give rise to pressure symptoms which may cause a fatal outcome before any signs of cachexia occur. Pain is one of the most reliable symptoms of mediastinal growths; it may be constant or paroxysmal and radiating. Dyspnea occurs from pressure on the trachea or bronchi; hoarseness from pressure on the recurrent laryngeal nerves. Pressure on the larger veins may result in cyanosis of the face, neck, and upper extremity. Cough is often a distressing symptom. The expectoration of sebaceous material with hair, etc., points to the rupture of a dermoid cyst into the trachea or one of the bronchi. Bulging of the sternum or ribs, erosion of the bone and flatness to percussion over normally resonant areas are among the frequently encountered physical signs. A unilateral or bilateral edema of the chest wall from pressure on the azygos vein may be the only sign of a tumor of the posterior mediastinum. Generally, however, dysphagia or wasting from pressure on the thoracic duct will occur at a later period in growths in this region.

The **treatment** of mediastinal tumors has not been sufficiently developed to enable one to give any definite rules in regard to the procedures to be followed. Grave pressure symptoms may sometimes be relieved by resection of the sternum and ribs. If the diagnosis of tumor can be made sufficiently early to give a reasonable hope of success radical treatment may be undertaken.

OPERATIONS UPON THE THORAX.

Paracentesis.—This operation is indicated for the removal of an effusion, fluid, blood, or air in the pleural cavity. The site selected for the introduction of the aspirating needle should be wherever the physical signs indicate the presence of the intrapleural fluid. In general it may be stated that unless the fluid is encapsulated and limited to a definite region the puncture should be made in the midaxillary line in the sixth or seventh intercostal space, or on a line with the angle of the scapula in the eighth or ninth space. As a rule no anesthetic is required. The patient may sit upon an ordinary chair with the head and shoulders bent forward and slightly to the opposite side, or may lie upon the sound side with a pillow or sand-bag under the chest. The skin should be rendered sterile. A local anesthetic may be used, if desired, or if the patient is a child. The arm should be raised and the skin drawn slightly upward. The upper margin of the rib bounding the inferior limit of the space should be carefully recognized and the needle thrust inward and slightly upward, the point of the needle entering above the upper margin of the rib. As soon as the point of the needle is felt to be in the pleural cavity, the aspirating tube should be attached and the air or fluid withdrawn. When this has been accomplished the needle should be quickly withdrawn and the small cutaneous wound sealed with adhesive plaster or a cotton and collodion dressing.

The Establishment of an Artificial Pneumothorax.—This procedure is indicated in certain cases of hemorrhage from an injured lung; for the cure of chronic pulmonary abscess which has ruptured into a bronchus, and in which no pleural adhesions are present to prevent collapse of the lung; in certain cases of bronchiectasis and in early tuberculosis.

It has been demonstrated experimentally that the disappearance of air from a closed pleural cavity is largely due to absorption of the oxygen, the nitrogen being absorbed very slowly. For this reason Murphy advocates the introduction of pure sterile nitrogen gas for the production of an artificial pneumothorax. The patient is prepared as for a paracentesis. A local anesthetic may be used, if necessary. A sterile trocar and cannula should be introduced down to the rib and the trocar withdrawn. The cannula is then connected with a reservoir of sterile nitrogen gas by means of a sterile rubber tube and the cannula then pushed above the upper margin of the rib into the pleural cavity. As soon as this is reached the gas will flow into the pleural sac and compression of the lung will follow. From 500 to 2000 ccm. of gas may be introduced. A pneumothorax thus created will generally endure for from ten to twenty weeks. The operation is devoid of danger and may be repeated as often as the necessities of the case require.

Thoracotomy.—This operation is occasionally indicated for the removal of infected or purulent effusions in the pleural cavity, where prolonged drainage is not necessary. The site is usually the same as for paracentesis. The patient should lie upon the healthy side, over a

sand-pillow, by which the thorax is arched upward and the intercostal spaces widened. Local anesthesia is all that is required in the majority of instances. After the parts have been cocainized an incision 4 or 5 cm. in length should be made midway between and parallel with the ribs. The skin, fasciæ, and muscles should be divided until the internal intercostal aponeurosis is reached. After all bleeding points have been secured the presence of fluid should be demonstrated by aspiration and the pleural cavity opened by incision or by enlarging the puncture made by the aspirating needle with dressing-forceps or scissors. After the fluid has been evacuated a firm and not easily collapsible rubber drainage-tube should be introduced and a sterile dressing applied. There is a strong tendency in these wounds to close by approximation of the ribs, and for that reason the operation is not to be recommended when prolonged drainage is necessary.

Thoracotomy with Resection of a Rib.—This is the operation of choice in all cases where drainage of the pleural cavity is required. The extra time consumed in the resection of the ribs is not more than two minutes, and most surgeons now adopt this procedure in preference to simple thoracotomy. The site of operation and the position of the patient are the same as in thoracotomy. The operation can be performed with local anesthesia, but in children and nervous individuals general anesthesia is to be preferred.

A cutaneous incision, 4 or 5 cm. in length, is made directly over the rib to be resected. The tissues including the periosteum are divided to the bone, the periosteum is then stripped from the bone by a raspatory or periosteal elevator, both in front and behind, care being taken in removing the membrane from the groove on the inferior border of the rib to avoid wounding the intercostal vessels and nerve. As soon as the bone is freed from its periosteum, a segment of the rib 3 or 4 cm. in length is removed with bone-forceps or the Gigli saw. When the bleeding has been arrested the cavity is opened by an incision through the periosteum, internal intercostal aponeurosis, and parietal layers of the pleura (Fig. 319).

One or more rubber drainage-tubes should then be introduced or the Wilson double-flanged tube shown in Fig. 315. It is sometimes necessary to excise more than one rib to allow digital exploration of the thoracic cavity or other intrapleural manipulation. This can generally be accomplished through one incision made somewhat longer to allow greater retraction of the soft parts. Each rib should be exposed and resected subperiosteally in the same manner as indicated above.

Osteoplastic Thoracotomy.—This operation is indicated when for any reason it is desirable to inspect a large area of the thoracic cavity or to perform an operation on the heart or lungs which requires the introduction of the hand into the pericardium or pleural sac.

The usual site for this operation is on the anterior aspect of the chest near the sternum, although it may be undertaken with slight modification in any other situation.

In the anterior operation, a vertical incision 12 or 15 cm. in length

is made parallel with the external border of the sternum and from 1 to 2 cm. from it. From the upper and lower extremities of this incision two horizontal cuts are made outward over the ribs. The incisions are carried downward to the ribs and costal cartilages. When these and the intercostal spaces are cleared, the internal mammary vessels are exposed by division of the intercostal tissues near the external border of the sternum and ligated above and below the costal cartilages to be

Fig. 319.—Resection of Rib for Empyema.

resected. When all bleeding has been arrested the costal cartilages are divided near the sternum and the pleural cavity opened by cutting through the remaining soft tissues in the line of the incision through the cartilages and along the upper and lower intercostal spaces. The rectangular flap thus formed is raised and bent outward, fracturing the ribs along the attached portion (Fig. 320). When the necessary intrathoracic procedures have been carried out the flap is accurately replaced, sutured, and the wound dressed, with or without drainage.

Many surgeons prefer to divide the ribs at the outer extremity of the wound and use the inner extremity as a hinge. The disadvantage of this procedure is that in turning back the flap the internal mammary vessels may be injured.

Decortication of the Lung (Fowler's Operation).—This operation consists in stripping the firm fibrinous envelope from the surface of the retracted lung and allowing it to expand and fill the pleural space.

This procedure is also known as Delorme's operation, but to Fowler belongs the credit, as his report was published in the *New York Medical*

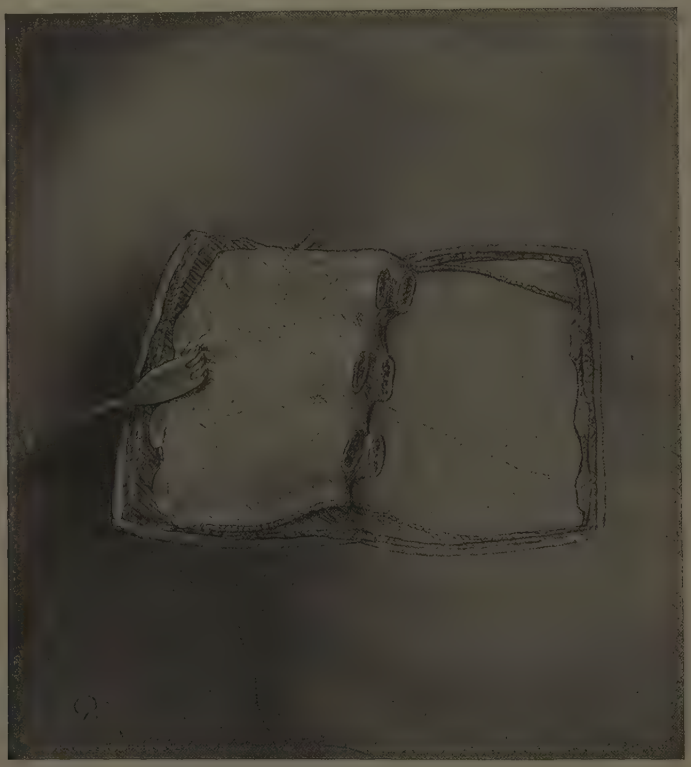

FIG. 320.—OSTEOPLASTIC THORACOTOMY.

Record for Dec. 30, 1893, while Delorme's appeared in the *Gazette des Hôpitaux*, 1894, No. 11. It is indicated in cases where the lung fails to expand after adequate drainage of the pleural sac.

The pleural cavity should be freely opened by resecting portions of three or four ribs or preferably by the osteoplastic flap operation. An incision is then made through the fibrinous exudate on the surface of the lung and the membrane stripped from its surface and removed with scissors. In favorable cases the lung will immediately expand and eventually obliterate the dead space. The operation seems to be most successful in children, and where the interval between the first drainage and the secondary procedure has not been sufficiently long to produce

interstitial changes in the lung which prevent expansion. In Fowler's first case the disease had existed for two years. As a rule, however, satisfactory results cannot be expected if the operation is undertaken after four or five months have elapsed since the primary drainage. In a certain number of cases it will be found to be impossible to strip the membranous envelop from the visceral pleura without serious damage to the lung tissue. Where this condition exists it is useless to proceed further with the operation.

Thoracoplasty.—The object of this operation is to obliterate the dead space between the retracted lung and the chest wall and thereby bring about healing of an obstinate empyema sinus or cavity.

Estlander's Operation.—This consists in the removal of portions of several ribs with a view to rendering the external wall of the suppurating dead space more elastic and to allow it to be depressed and brought in contact with the collapsed lung. The number and the extent of the ribs to be resected will obviously depend upon the size and shape of the space to be obliterated. Estlander's original plan was to remove the ribs only, leaving the intercostal muscles, aponeurosis, and thickened pleura to form with the superficial muscles and skin the outer wall of the obliterated cavity. The exposure of the ribs may be made by raising a single U-shaped flap of skin and superficial muscles, by making a double rectangular flap, or by making several horizontal incisions over intercostal spaces, through each of which two ribs may be resected.

When all of the bony structures have thus been removed from the external wall of the suppurating cavity, the soft parts are pressed downward until firmly in contact with the lung and held in this position by pressure of the outside dressings until union has taken place. Estlander later modified the operation by removing the intercostal muscles, aponeurosis, and thickened parietal pleura, and advised scraping the pyogenic membrane from the lung surface. The modified operation is, therefore, very similar to Schede's.

Schede's Operation.—This operation has for its object the obliteration of the larger cavities resulting from complete retraction of the lung, so that no part of the visceral pleura is in contact with the anterior wall of the chest. It consists in the removal of the ribs from the second to the tenth or eleventh, together with the intercostal muscles, the internal intercostal aponeurosis, and the parietal pleura. The incision begins over the costal cartilage of the second rib, passes downward along the cartilages to the tenth, along the upper border of the tenth rib to a point near its angle, and then upward along the vertebral border of the scapula to the second interspace. All of the superficial structures are divided to the ribs and intercostal muscles, and the large U-shaped flap thus outlined is dissected upward, carrying with it the scapula and its attached muscles. When all bleeding points in this large flap have been secured the costal cartilages are divided by forceps and the posterior extremities of the ribs similarly divided near their tubercles.

The anterior and posterior cut ends of the intercostal vessels are

secured by ligatures in the spaces created by division of the ribs, and the entire mass, consisting of ribs, intercostal structures, and thickened parietal pleura, is removed by heavy scissors. The visceral pleura is then thoroughly cureted and the muscular and cutaneous flap placed in contact with the contracted lung and sutured in place by heavy catgut mattress sutures for the muscles and the silk or silkworm-gut sutures for the skin. A space for drainage should be left at the lower portion of the wound and the dressing so arranged as to insure contact of the flap with the lung throughout its entire extent. The operation is one of the severest in surgery, and should not be undertaken unless the surgeon is provided with competent assistants and every facility for meeting and controlling severe shock.

FIG. 321.—SCHEDE'S OPERATION (COMPLETE) FOR GANGRENE OF LOWER LOBE OF RIGHT LUNG AND GANGRENE OF ENTIRE PARIETAL PLEURA FOLLOWING EMPYEMA.

Side of chest including first rib removed, together with lower half of scapula, in order to permit of easy adjustment of skin-flap. Gangrenous lower lobe of lung had previously been removed. At time of operation the upper lobe was decorticated according to Delorme. Complete recovery without sinus after one operation. (Case in practice of Leonard Freeman, of Denver, Colorado. Photograph by Dr. H. G. Stover, of Denver.)

Pneumectomy. — This operation, which consists in the resection of a portion of the lung, is occasionally indicated in cases of malignant growth, severe laceration or other destructive traumatic lesions, in cases of extensive gangrene, and very rarely in early isolated tuberculous deposits.

Experiments by Murphy, Ricketts,[13] Green, and others have demonstrated that large portions of the lung, in healthy animals, can be removed with comparatively little risk and with practically no untoward after-effects. The removal of a diseased or injured portion of the lung in the human subject, however, has thus far been attended by a high mortality.

The lesion is exposed by the resection of one or more ribs or by an osteoplastic flap, as described above. The lung is grasped by the hand and delivered through the thoracic wound, transfixed behind the lesion, and secured by one or more heavy chromic catgut mass ligatures. The diseased or injured portion is then cut away and the stump returned to the pleural cavity. The external wound is completely closed if the pleura is free from infection; otherwise drainage is established. Tuffier exposed the pleura by an intercostal incision without resection of a rib, separated the parietal pleura from the thoracic wall, creating thereby an extrapleural pneumothorax, palpated the lung through the relaxed parietal pleura, located the lesion, and then through a small pleural

incision delivered the diseased apex and removed it. Instead of transfixing and ligating the lung in the ordinary way, Green [14] introduces a subpleural, heavy silk, encircling suture with a blunt-pointed needle, draws this tight, removes the distal portion of the lung, and afterward unites the pleural edges with a continuous suture of catgut (Figs. 322, 323, and 324).

Anterior Mediastinal Thoracotomy.—This operation has for its object the exposure of the structures contained in the anterior half of the mediastinal space. The simplest method is by a temporary osteoplastic resection of a part of the sternum.

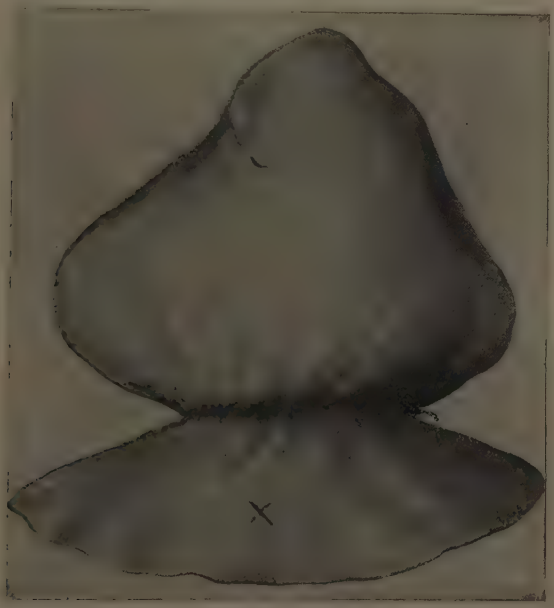

FIG. 322.—GREEN'S METHOD OF PNEUMECTOMY.

This represents the subpleural suture as drawn tight and tied. The portion X is then cut away, leaving a V-shaped wound of the lung, which is then sutured as in Fig. 323, bringing the edges of the wound together and coapting the pleural edges as in Fig. 324 (but not opposing the serous surfaces as in the Lembert suture of the peritoneum). This covers in the ligating suture and shuts off the cut edges of the bronchial tube from the free pleural cavity.

The patient should be placed in the dorsal position and two horizontal incisions made to the bone, the upper crossing the sternum on a level with the upper margin of the second costal cartilage, the lower crossing the bone just below the lower border of the fifth cartilage. A vertical incision is made just to the left of the sternum, connecting the left extremities of the two horizontal cuts. The second, third, fourth, and fifth left costal cartilages should be divided with bone-forceps, great care being taken to avoid wounding the pleura. The bone is next sawn through in the line of the upper and lower horizontal incisions and the rectangular flap thus outlined, raised, and turned backward to the right, bending or breaking the right costal cartilages (Fig. 325). During all of these steps great care should be taken to avoid separating the

superficial soft parts from the detached piece of bone, and in raising the bone flap to avoid opening the pleural or pericardial cavities.

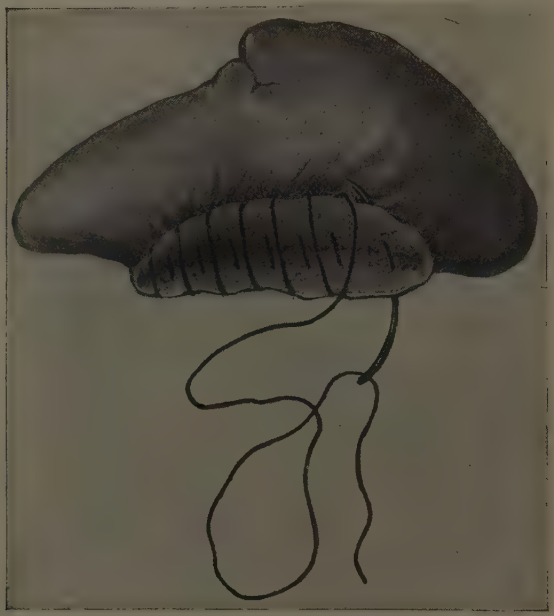

FIG. 323.—GREEN'S METHOD OF PNEUMECTOMY.
This represents the ligating suture as tied and the distal portion of the lung cut away, with the second or coapting suture in place, ready to draw up and tie.

This operation gives ample exposure for most operations on the superficial structures of the mediastinum. When the necessary operative procedures have been carried out the bone flap is replaced and

FIG. 324.—GREEN'S METHOD OF PNEUMECTOMY.
This represents the completed operation on the lung.

secured with sutures, a deep layer of chromic catgut uniting the periosteum and divided muscles; and sutures of silk or silkworm-gut for the skin. Another method, known as Milton's operation, consists in making a complete longitudinal median section of the sternum and

retracting the two halves of the bone. The cutaneous incision should begin in the median line just below the thyroid cartilage and extend downward to the ensiform. The upper part of the incision should be gradually deepened until the trachea is exposed in the suprasternal notch; the lower portion should be carried down to the bone and the junction of the gladiolus, with the ensiform separated. The soft parts should next be separated from the posterior surface of the sternum at the suprasternal notch and at the lower extremity of the bone, by the finger or a periosteal elevator, care being taken to hug the bone closely and to avoid opening the pleural cavity and wounding the great vessels, especially the veins. The bone should then be sawn through in the line of the incision, preferably with Hey's saw. When, in sawing, the posterior compact plate is reached the underlying structures should be protected by the introduction of a steel spatula from above and below,

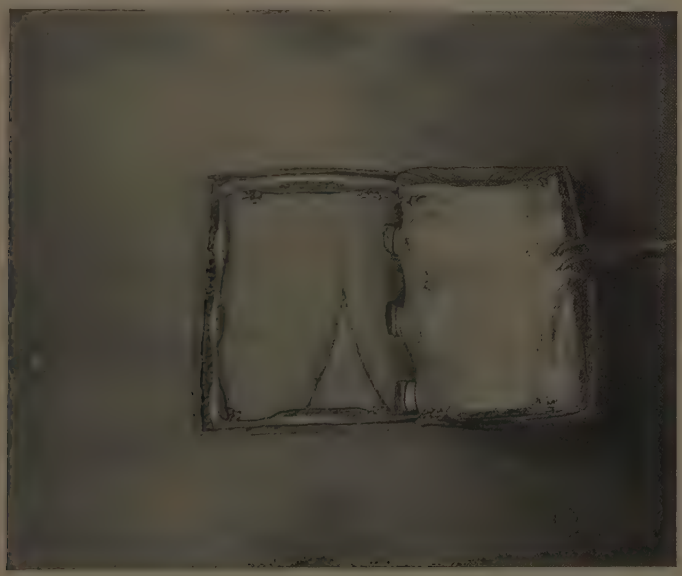

Fig. 325.—Anterior Mediastinal Thoracotomy (Bryant's Operation).

and the bone completely divided in these regions. In the middle of the bone a very thin plate may be left which can be broken by retraction of the divided edges or cut with thin bone-forceps. When the bone is completely divided it should be retracted with great care, pressing the underlying structures away from it by means of the fingers or gauze pads until a space from 6 to 8 cm. is obtained. Through this opening the necessary operative procedures can be carried out, after which the separated portions of the bone are brought together and held by three or four heavy chromic catgut sutures passed through drill-holes. The cutaneous wound is united in the usual manner and the wound dressed with sterile gauze surrounded by a snugly applied bandage or a chest binder.

Posterior Mediastinal Thoracotomy.—This operation is indicated for the removal of foreign bodies from the esophagus or bronchi, for the evacuation of posterior mediastinal abscesses, or for purposes of exploration.

Bryant's operation is as follows: The patient should be placed in Syms' position, the side to be operated upon being uppermost, and the arm raised well above the head to widen the intercostal spaces. The exact site of operation should be determined by the position of the lesion. In general the opening should be about 10 cm. in each diameter. The cutaneous incisions should be in the form of three sides of a square, the base of the flap being in the median line over the spinous processes.

FIG. 326.—POSTERIOR MEDIASTINAL THORACOTOMY (BRYANT'S OPERATION).

This incision should be deepened until the ribs are reached and the heavy musculocutaneous flap retracted toward the median line, exposing three ribs from their angles to their junction with the transverse processes. After all bleeding points have been secured, the middle rib should be resected subperiosteally and the two others divided at each extremity, but not separated from their intercostal muscles. An incision is next made parallel with the ribs through the periosteal bed of the central removed rib, and through this opening the underlying pleura should be gently separated by the finger from the surrounding area. When the pleura has in this manner been separated from the

posterior surface of the remaining two ribs and the attached intercostal muscles, two additional incisions are made in the intercostal aponeurosis at right angles to the extremities of the central incision, making an H-shaped cut. This allows two flaps containing the two remaining ribs to be raised and retracted out of the way (Fig. 326). By gently separating the pleura from the bodies of the vertebræ the posterior mediastinal structures are exposed. If the operation has been undertaken for the removal of a foreign body in the esophagus, the body is located by palpation, the esophagus incised, and after removal of the foreign substance united with two rows of catgut sutures. If the object of the exploration has been for the removal of some body in the bronchus, its exact location should previously have been ascertained by the *x*-rays or bronchoscopy. The bronchus is now incised and an attempt made to extract it with forceps, hooks, or a strong electromagnet.

After the necessary operative procedures have been carried out the two retracted ribs should be sutured in place and the musculocutaneous flap replaced and united with deep and superficial sutures. Drainage should be introduced if the esophagus or bronchus has been opened or if any infection is present.

The Advantage of Sauerbruch's Cabinet in Operations upon the Thorax.—One of the greatest dangers in intrathoracic operations is the occurrence of pneumothorax as soon as the pleural cavity is opened. This, when limited to one side, while not necessarily fatal, always causes more or less serious respiratory embarrassment and renders such operations hazardous. When both cavities are opened the result is generally rapidly fatal. As it not infrequently occurs in operations upon one side of the thorax that the opposite lung is more or less incapacitated as a result of injury or disease, the desirability of avoiding the serious consequences of pneumothorax has long been appreciated by surgeons.

A large amount of careful experimental work has been carried out to find some means of avoiding the serious respiratory and circulatory disturbances which obtain whenever operations associated with extensive pleural openings are undertaken. The experiments have mainly followed two plans: the first being to increase the air pressure within the bronchial tubes and thus prevent a collapse of the lung when the negative pressure on the surface of the lung is removed by opening and admitting air to the pleura; the second plan being to diminish the atmospheric pressure on the exterior of the lung when the chest is opened, while maintaining the normal pressure of the air entering the trachea. Experiments with the former method have generally been carried out by means of a snugly fitting tracheal cannula or intubation tube, and some form of air-pump or bellows (Matas,[15] Fell,[16] Hans Meyer[17]); the latter method, by placing the animal's body, below the neck, in an hermetically sealed chamber from which a certain amount of air has been withdrawn (Sauerbruch[18]). F. T. Murphy,[19] of Boston, has devised an ingenious etherizing apparatus in the form of an air-tight helmet,

which incloses the patient's head and neck and in which the air pressure is increased and maintained by water displacement. Nathan W. Green[20] has recently reviewed the entire subject and given the results of some very successful experiments with artificial respiration by a positive pressure plan, in which he employed the Hans Meyer pump and an original etherizing apparatus and intralaryngeal cannula.

Sauerbruch, of Breslau, however, has given the subject the most attention and has devised a plan whereby the deleterious effects of pneumothorax can be entirely overcome. He devised an air-tight cabinet in which he performs such operations under diminished atmospheric pressure. The cabinet is constructed of metal and glass and is so arranged that the body of the patient lies upon a table within the cabinet while the head protrudes through an opening in one side

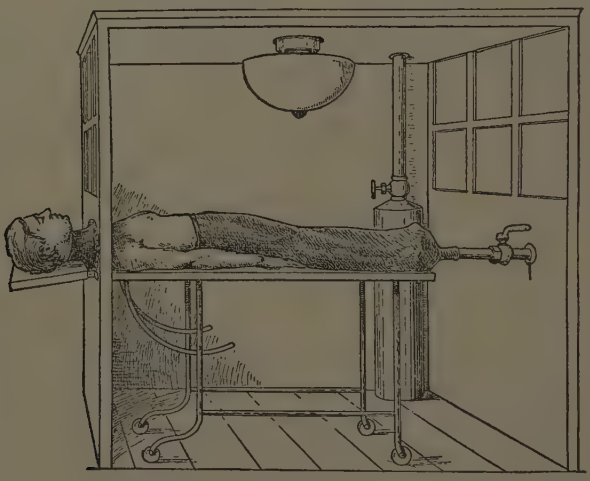

FIG. 327.—SAUERBRUCH'S CABINET.
Position of patient in chamber ready for operation under negative pressure.

guarded by a tightly fitting rubber collar or ring, which is snugly applied around the neck (Fig. 327). The cabinet is sufficiently large to accommodate the operator and two or three assistants.

Air is exhausted from the cabinet and a negative pressure produced by an electric suction-pump. The cabinet is amply lighted by electricity and contains a telephone, by which communication may be had with outside assistants. Later an anteroom was added (Fig. 328), also air tight, and communicating with the main chamber and the outside by means of two air-tight doors. As the suction-pump also communicated with this anteroom, it was possible to call for additional instruments from the outside and have them placed in the anteroom and afterward brought to the main compartment without altering the air pressure. When the patient is placed on the table with the head protruding, the entire body below the waist is surrounded by a canvas-covered rubber sac, which communicates with the outside air by means

of a straight tube, thus maintaining the ordinary atmospheric pressure upon all parts save the thorax and arms. The anesthetic is administered by an outside assistant.

When sufficient air is withdrawn to render the negative pressure equal to 10 or 12 mm. of mercury, it was found that in opening both pleural cavities the lungs did not collapse, but respiration continued without the slightest embarrassment. By means of this cabinet Sauerbruch was able to carry out extensive operations upon the thoracic portion of the esophagus and other mediastinal structures in which both pleural cavities were freely opened. Many strikingly successful

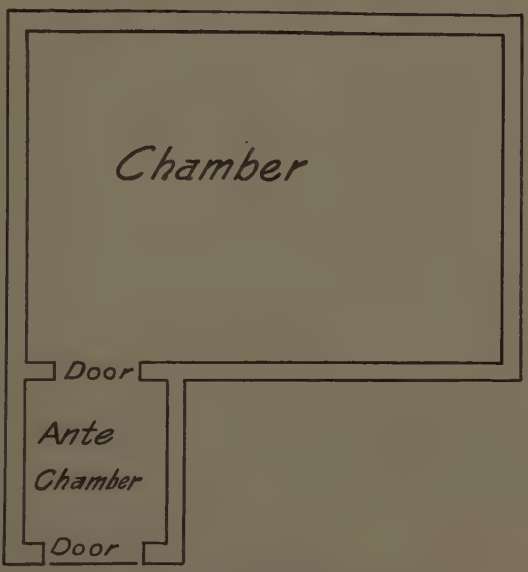

FIG. 328.—SAUERBRUCH'S CABINET.
Showing the relation of chamber and antechamber.

animal experiments have been performed, including extensive resections of the esophagus and esophagogastrostomy (see p. 944), clearly demonstrating the practicability of the plan. In clinical work upon the human subject the use of the cabinet has proved of the greatest advantage. Sauerbruch has recently reported 16 cases in which he employed this method for intrathoracic or mediastinal operations with encouraging results[21]; and while several of the operations undertaken for grave conditions, as carcinoma of the esophagus or of the cardia, resulted fatally, the cause of death was in no instance attributable to the sequelæ of pneumothorax.

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CHAPTER XLII.

SURGERY OF THE BREAST.

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The origin of the mammary gland is still a subject of controversy among embryologists. That it has its beginning in the specialization of a group of epidermal glands seems assured. Opinions differ, however, as to whether the milk gland is evolved from the sebaceous or from the sweat gland. According to Minot: "The latter opinion rests upon strong evidence, the former principally upon the analogy of there being considerable fat in both the sebaceous and lacteal secretions." The weight of evidence seems clearly in favor of the sudoriparous origin of the milk glands, both as regards their embryologic development and the mechanism of the secretory function.

In the human embryo toward the end of the second month a localized thickening of the epidermis makes its appearance. This is formed entirely by the proliferation of the germinal layer which penetrates into the cutaneous derma. This latter assumes a rounded form with a slight external protuberance corresponding to the location of the nipple. Later this epithelial hypertrophy projects downward from the epidermis into the dermis, gradually enlarging. At the same time the cells in its central portion begin to cornify and fall out, so that the ingrowth becomes hollow. The mammary gland is formed by budding from the deeper portions of this primary epidermal mass. This process may not be completed until at about the time of birth or a little after. Further budding and branching of the epithelial ingrowth takes place at about this time, giving rise to the milk glands proper, with their terminal branched glandular portion. Outside and surrounding these glandular elements can be seen at an early date the fibrillar connective-tissue stroma within which the glands themselves develop and grow.

ANATOMY.

The mammary glands, together with the skin and a considerable quantity of fat, form two hemispheric eminences situated on either side of the thorax, anteriorly. The nipple, a conic body, is situated a little below the center of each breast, and points slightly outward and upward.

Posteriorly, the breast lies upon the pectoralis major muscle, external oblique muscle of the abdomen, and the serratus magnus. There is a prolongation of the breast extending up into the axilla as high as the third rib and known as the "axillary prolongation" or "axillary tail," which lies upon the serratus magnus and pectoralis major and is sepa-

rated from the axilla by the axillary fascia. The outline of the gland is irregular. Extensions of parenchyma along the ligaments of Cooper, prolongations downward to and even into the pectoralis major muscle, and radiations out into the surrounding fat have been demonstrated by both Heidenhain and Oelsner.

The vertical diameter extends from the lower border of the second rib to the sixth or seventh rib, and the horizontal from about the sternal margin at the level of the fourth rib to the fifth rib in the mid-axillary line.

Structure of the Nipple.—The nipple is formed by an elevation of dark wrinkled skin, at the summit of which are the openings of about twenty lactiferous ducts, or one for each lobe of the gland. The nipple is surrounded by a circle of the same dark-colored skin, the areola, about the margin of which can be seen a number of small elevations representing large sebaceous glands (tubercles of Montgomery). During pregnancy the areola enlarges and the color becomes darker, and at the same time the sebaceous glands become more prominent. Beneath the nipple and areola one finds the lactiferous ducts radiating toward the nipple, and situated in a loose connective tissue free from fat. Radiating bands of plain muscle-fibers extend from the base to the apex, and about the base there is a bundle of circular fibers. These have the function of producing erection.

Structure of the Mamma.—The adult gland in the female consists of fifteen to twenty lobes. The spaces between these lobes are filled with adipose tissue. Connecting the anterior surface of the gland and the overlying skin are a number of fibrous bands (ligaments of Cooper), including lobules of fat in their meshes.

Each lobe may be considered as a distinct gland, being provided with an excretory duct, branching ducts and acini, and may be subdivided into smaller lobes, and these again into lobules. Each lobule consists of a duct with its acini situated in a loose myxomatous intralobular connective tissue, the whole surrounded by the denser interlobular stroma carrying the vessels and nerves. The acini are lined with flattened epithelium on a basement membrane, the ducts by a single layer of low columnar cells. The ducts unite to form fifteen to twenty larger ducts, which converge toward the nipple, beneath which they become dilated to form ampullæ.

Before puberty the glands in both sexes are alike. At puberty in the female the gland enlarges, owing to the formation of acini and the development of the intralobular stroma. With pregnancy there is a new formation of acini as well as an increase in size of those pre-existing. After pregnancy the gland returns to its previous condition.

Blood Supply.—The arterial supply of the breast is derived from three main sources: (1) The anterior intercostal arteries, branches of the internal mammary, which perforate the intercostal muscles and supply them and the mammary gland; (2) the perforating branches of the intercostal arteries, and (3) the long thoracic, which anastomoses with the other two.

Around the base of the nipple there is an anastomotic circle of veins called the "circulus venosus," from which large veins transmit the blood to the circumference of the gland. Thence it is carried to the larger venous trunks corresponding to the arterial supply.

Nerve Supply.—The principal nerve supply is derived from branches of the intercostals and filaments of the external and internal anterior thoracics and the posterior thoracic nerve.

The anatomy of the lymphatic supply of the mammary region will be discussed under Cancer of the Breast, with especial reference to the avenues of extension of the carcinomatous process.

CONGENITAL ANOMALIES.

Anomalies and defects in the structure of the mammary gland are due to arrested development or to a reversion to primitive types. This may take place at any stage of its evolution. These defects have been observed in males as well as females and may involve one or both breasts in the same individual. They have been observed not infrequently in association with other malformations—*e. g.*, of the genitalia, pectoral muscles, chest wall, and in acephalic monsters.

Amastia.—If the arrest in development begins early, before the third month *in utero*, it may result in complete absence of the gland. This may be unilateral or bilateral. Both are of extremely rare occurrence.

Polymastia.—On the other hand, and occurring with much greater frequency, is the presence of a plurality of milk glands, more or less developed. These accessory glands, when present, are found most often above the level of the umbilicus along a line drawn from the axilla to the groin, the "milk line," and are apt to occur in pairs. They have been observed in other localities, "mammæ erraticæ," *e. g.*, the middle line anteriorly, axilla, hip, thigh, buttock, back, abdomen, vulva, etc. In a very few instances they have been found springing from the inner wall of dermoid cysts of the ovary. Their most frequent site is about 8 cm. below and internal to the normal breast. The majority of the so-called axillary mammæ in the female are in all probability simply extensions or sequestrations from the true breast.

These supernumerary mammæ vary greatly in size, shape, and histologic structure. Some contain the merest rudiments of glandular tissue and are functionless, while others are well developed and may even secrete milk. In some cases the nipple alone is present without demonstrable gland tissue, in others the aberrant gland is either without a nipple or it may be furnished with more than one.

It is an interesting fact that the occurrence of neoplastic changes in true supernumerary breasts is almost unknown, only one or two doubtful cases having been so far reported.

The only **treatment** to be advised is excision of the superfluous structures, if for cosmetic or other reasons it appears to be indicated.

Micromastia.—When the arrest in development is incomplete,

there results a small imperfectly formed gland. It may affect one or both glands, and when so affected they are found to be functionless.

Athelia.—The nipple is the seat of developmental disturbances similar to those which are observed in the breast. When this arrest occurs early and is complete, we have entire absence of the organ—athelia. When it occurs later and is only partial, minor degrees of malformation are the result. These are of comparatively frequent occurrence and manifest themselves in the form of small, flattened, depressed, or inverted nipples.

Polythelia.—Supernumerary nipples are relatively common and are found with greater frequency in the male than in the female, in the proportion of 2 to 1. The number of these additional structures may vary from one to as many as eight. The deformity may consist only of a bifid condition of the nipple, two nipples surrounded by one areola, multiple nipples attached to the same breast, or they may be found in parts more or less remote from the normal situation.

The only treatment to be recommended is excision.

ATROPHY.

In addition to the congenital defects and atrophies of the mammary gland which have been referred to, certain pathologic atrophies due to the effects of traumatism and disease are also met with. Severe injuries or inflammations at or soon after birth have been observed to result in partial or complete arrest of development of the gland.

Senile Atrophy.—At the menopause the parenchyma becomes atrophied, giving place to the outgrowth of fibrous stroma and fat, of which in old age the breast proper is almost entirely composed. The microscopic picture of a senile breast shows little else than fibrous tissue and fat, the latter appearing occasionally in excessive quantity, with only here and there a duct, and at rare intervals a few acini. The remaining ducts and glandular elements are prone to undergo cystic degeneration.

HYPERTROPHIES.

Enlargements of the breast other than those associated with inflammatory or neoplastic formations are congenital, physiologic, or pathologic.

Congenital.—At birth there is little or no difference to be found in the sexes in the structure and appearance of the breast. Some more or less imperfectly developed ducts and acini may always be found surrounded by loose connective tissue and fat. This during the first few days after birth undergoes rapid formative changes and cell proliferation in the ducts, and may occasionally hypertrophy and secrete a colostrum-like fluid.

Occasionally associated with precocious sexual development, hypertrophy of the mammary glands has been noticed in young infants.

Physiologic.—Up to the period of puberty there is no appreciable difference in the development of the mammary structures in the two

sexes. After this time in the male development ceases. In the female, on the other hand, the development is gradual and continuous until the function of menstruation has become well established. Still more marked hypertrophy is observed during pregnancy, and the acme of development is reached during lactation

Diffuse Hypertrophy.—Pathologic.—This is a relatively rare condition. Diffuse hypertrophy is always bilateral. Although instances of unilateral enlargement have been reported, it is quite likely that a more careful study of the removed tissues would have shown them to have been fibro-adenomata. Two varieties of this affection have been described: (1) Virginal. (2) During gravidity. The latter is the less common of the two.

Little definite is known as to the etiology of this form of mammary hypertrophy. Race, heredity, climate, and hygienic conditions apparently are not factors in its production. Puberty, pregnancy, and

FIG. 329.—DIFFUSE HYPERTROPHY OF FEMALE BREAST.
(Johnson's case.)

probably menstrual disorders are the only factors which exert any recognizable influence in the production of the disease.

(1) *Virginal hypertrophy*, of which 31 cases have been reported, usually begins about the time of puberty or a little later. The onset may be acute, but, as a rule, is slow and the increase in size gradual, covering a period of several years. Acute exacerbations may be observed from time to time. They are frequently associated with menstruation. The occurrence of pregnancy has not affected materially the course of the disease in those few cases in which it has been observed, but the secretion of milk is usually faulty or does not take place at all.

(2) *Hypertrophy during Gravidity.*—Of this variety 13 cases have been reported. The onset may be acute and the increase in size is in every instance rapid, since the enlargement reaches its acme by the end of the pregnancy and frequently wholly disappears after parturition. The breasts may or may not enlarge again with each succeeding pregnancy. As a rule they do. The enlargement may not appear at the first pregnancy, it has been observed to develop after the eighth pregnancy.

The size of the hypertrophied breasts attained in some cases is colossal. They have weighed as much as 30 pounds after removal, and by their very size have proved a menace to the comfort and health of their possessor. In virginal hypertrophy the duration is indefinite. In gravidity, hypertrophy may terminate with the pregnancy.

A section through the hypertrophied breast shows a smooth, white and glistening surface. There is present no special vascularity, no cyst formation. The tissues are firm and resistant. The subcutaneous fat is atrophied. Here and there can be seen sections of dilated ducts and evidences of parenchyma.

Microscopically the hypertrophy is seen to be due chiefly to the growth of young connective tissue, but there are also evidences of cell proliferation and hypertrophy in the parenchyma as well.

Treatment.—Palliative measures in the way of supporting bandages are indicated. In the virginal form amputation is the only hope of relief; it can be done in two sittings or both breasts at the same time. In the gravidity variety relief may be expected at the termination of the pregnancy, which may have to be artificially induced in aggravated cases.

CHRONIC CYSTIC MASTITIS (Koenig), **CYSTIC DISEASE OF THE BREAST** (Reclus), **CYSTADENOMA OF THE BREAST** (Schimmelbusch), **ABNORMAL INVOLUTION** (Warren), **SENILE PARENCHYMATOUS HYPERTROPHY** (Bloodgood).

As indicated by the multiplicity of names that have been suggested for this most interesting and important condition, there still remains a great diversity of opinion as to its pathology. The earlier observers, especially Koenig, believed it to be of inflammatory origin. Later writers, notably Schimmelbusch, attribute the process to an actual new growth associated with the formation of cysts. More recently it has been considered, especially by American authors, to be a definite parenchymatous hypertrophy, a product of abnormal involution.

As pointed out by Bloodgood, it makes little difference for practical purposes which it is, so long as its clinical picture is recognized and its great tendency toward malignant degeneration clearly understood. The important facts to be borne in mind in a consideration of the pathology of this condition are these: It is a lesion of the senile breast beginning at or a short time before the menopause, in women between forty and fifty years of age. It is observed only during the cancer period and the possibility of malignant disease must, therefore, always be borne in mind.

Pathology.—The pathologic picture is not a constant one, several types of the growth having been described:

(1) The distinguishing feature of the first type is the presence of smooth-walled cysts. They are usually multiple and of larger or smaller size. Their walls are lined at first by one layer of low columnar epithelium. Later, as the pressure from the retained secretion increases, the epithelial lining disappears. The fluid contents of these cysts is usually turbid and of greenish or brownish color, never bloody.

(2) In this variety the breast has recently been the seat of a subacute inflammation. Both the parenchyma and periglandular connective tissue exhibit evidences of a low-grade inflammation.

(3) This type is more distinctly adenomatous in character. Here both the glandular acini and the cysts are found filled with masses of cells due to cell proliferation from the walls or to a papillary outgrowth simulating an adenoma.

On fresh section (2) and (3) present a very similar appearance. The picture suggests that of fibro-adenoma, except that the process is diffuse and not encapsulated. The chief changes observed are dilatation of the ducts and acini. Papillomatous ingrowths are also

FIG. 330.—SENILE PARENCHYMATOUS HYPERTROPHY BECOMING ADENOCARCINOMA. (Bloodgood.) *Ad*, Adenocystic areas; *X*, adenocarcinomatous nodule; *N*, breast, first stage of hypertrophy; *C*, cyst in fibrous portion of breast.

frequently present. The interlobular connective-tissue stroma is well marked.

(4) This is the transition stage from the adenoma to the carcinoma. The pathologic picture presented cannot be distinguished from that of adenocarcinoma.

The importance of the early recognition of this condition is very great. The more nearly the anatomic picture corresponds to the adenomatous type the more likelihood of the later cancerous development. The more marked the cystic development and the larger the cysts, the less tendency there seems to be to the formation of cancer (Bloodgood).

The presence of localized areas of hypertrophy existing in one or both glands where atrophy is normally to be expected is typical of this

affection. Together with this hypertrophy is frequently associated an ectasia of the ducts and acini, which leads to the formation of cysts.

The **clinical picture,** like the pathologic, is not always easy to recognize. The disease may occur at any time of life, but it is observed more frequently at or about the menopause. One or both breasts may be affected. If found in young women, they are apt to be single or childless or who have not nursed their children. It rarely if ever occurs during lactation, but, as a rule, some years later. Previous mastitis seems to be a predisposing cause.

The greater part of the breast may be involved or only circumscribed portions of it. The affected portion of the breast gives the impression to the examining fingers of a more or less well-defined mass, moderately firm and hard, not closely attached to the skin or fascia, not red, but rather tender to the touch and at times painful, particularly during menstruation. There is no retraction of the nipple and rarely discharge therefrom, and no atrophy of the fat. The axillary glands may be enlarged, but are soft and show no metastases except in advanced cases.

Treatment.—The treatment should be influenced by the fact that in a large proportion of these cases, estimated at from 10 to 50 per cent. by various authors, carcinoma subsequently develops.

The condition is at first clinically benign and may remain so for years, but there is always, especially in the proliferating adenocystic type, the latent tendency toward malignancy. It is safer, therefore, always to excise the entire breast or both of them when the trouble is bilateral. Partial excision, except in selected cases where only one or two cysts are present, is not to be advised. Medical treatment is of no avail. A few cases have been observed to subside spontaneously. When there is a single cyst, aseptic aspiration has not seldom effected a cure, but is not to be recommended as a routine practice.

AFFECTIONS OF THE NIPPLE.

Inverted Nipple.—Retraction of the nipple may occur as a congenital deformity. It may result from injury or disease, *i. e.*, the pressure of the clothing, carcinoma, abscess, etc. It is one of the chief causes of eczema, fissures, and abscess of the breast, on account of the difficulty which the child has in nursing, thus producing trauma. This condition is of importance in the etiology of certain affections of the breast.

Inflammation of the Nipple.—Excoriations, cracks, and fissures constitute by far the greater number of the inflammatory affections of the nipple and areola. They occur most frequently during lactation as a result of lack of cleanliness. As a result of such lesions small abscesses, which are often multiple, may form in the areola. The burning, itching, and pain produced by these conditions are often severe and out of all proportion to their size. Keeping the nipples dry and clean, together with the use of an artificial nipple or discontinuing

nursing altogether, are usually sufficient to bring about a prompt cure. Deep fissures which persist for any length of time should be cauterized with silver nitrate.

Eczema of one or both nipples may occur independently of pregnancy and lactation. The symptoms and treatment do not differ from eczema elsewhere. The chronic forms may be difficult to differentiate from Paget's disease.

Tumors of the Nipple and Areola.—Sebaceous cysts originating in the glands of Montgomery are the most frequent tumors in this region. Papillomata, angiomata, etc., are occasionally met with in this situation. They are easily recognized and should be treated as similar growths elsewhere.

Paget's Disease of the Nipple.—See Carcinoma of the Breast.

AFFECTIONS OF THE INTEGUMENT OF THE BREAST.

The skin and subcutaneous tissue overlying the breast are subject to the affections common to the integument of other parts of the body. There is no special affection incident to the dermal structures of this region that occurs with unusual frequency.

Among the diseases which have been observed to occur in this region and which one may be called upon to diagnose are erysipelas, herpes zoster, scabies, chancroid, lupus, keloid, lipoma, fibroma, nævus, etc.

In the examination of these cases if proper care is taken to observe that the affection does not involve the breast itself, mistakes in diagnosis may frequently be avoided.

FUNCTIONAL DISTURBANCES.

Galactocele.—A cystic enlargement of one of the milk-ducts due to obstruction or obliteration, complete or partial, is a rare affection. It develops almost invariably in connection with lactation, although in rare instances it has been observed to make its appearance either before or long after a pregnancy. The contents of the cyst are at first pure milk. Later, owing to the absorption of the fluid contents or to clinical changes, it may become thick and creamy, cheesy, or oily in character.

Microscopically it is found to be composed almost entirely of fat globules. The consistency of the tumor depends upon the nature of the contents—if fluid, fluctuation is present; if semisolid, it may be absent. The tumor may be single or multiple, more often the former. They rarely attain large size, although enormous proportions have been reached in a few instances. As a rule, they are found beneath the areola near the nipple, although they have been found in other portions of the breast and deeply seated. They make their appearance rather suddenly without any inflammatory changes and with little pain or tenderness. Examination reveals a rather small, smooth, round, or ovoid swelling, compression of which may cause milky fluid to exude from the nipple,

but this is uncommon. The skin over it is not adherent. It can be freely moved upon the pectoral fascia beneath. The surrounding breast tissue is not infiltrated. The tumor may persist for years, giving little or no discomfort, as in a case I have recently observed.

It is probable that the process is the result of primary obstruction and secondary distention of the milk-ducts due to retained secretions, but there may be rupture with extravasation of the contents in extreme cases. Inflammation, abscess, ulceration, and suppuration with the formation of persisting milk fistulæ have been observed to develop in the course of the trouble, but are infrequent complications.

Aspiration of the contained fluid or aspiration with injection of iodin are not to be recommended. Incision with subsequent packing of the cyst cavity with iodoform gauze in selected cases may be admissible. Excision of the entire cyst wall with immediate suture of the wound will give the best results in the majority of cases. Amputation of the entire breast is not seldom required.

Neurosis, Mastodynia, Irritable Breast.—It occasionally happens that young adult women are the subjects of periodic pains in the breast, more or less intense. At puberty, during menstruation, and at the beginning of pregnancy are the times when these disagreeable sensations are most pronounced. Rarely the disturbance amounts to intense pain. Objectively, there is little or nothing to be made out. Subjectively, the symptoms may vary from slight hyperesthesia to agonizing pain, which may be confined to a small area or may involve the whole side of the thorax and the arm. One or both breasts may be involved and the pain and hyperesthesia may be so intense and persistent that nothing short of amputation of the entire breast will avail, as in a recent case of my own. Palliative treatment, local and hygienic, should always be tried. Resection of the affected nerves may prove efficacious. When other diseases are present—*e. g.*, gout or rheumatism—appropriate treatment should be instituted.

MASTITIS.

The mammary gland is the subject of inflammatory changes which differ little from similar changes in other structures. Different classifications have been made with reference to the various periods of life at which the inflammations occur: to the cause, to the structures involved, to time, acute, chronic, etc. It is frequently impossible to differentiate the one from the other. Indeed, for practical purposes, it is not always necessary to do so.

Mastitis Neonatorum.—As has been previously pointed out, the breasts of the newborn of both sexes are subject to hypertrophy and, frequently associated with this, they may also be the seat of inflammatory changes. The condition is of little importance and usually resolves in a few days unless the affected breast is manipulated or irritated, in which case it may go on to suppuration, when it should be treated as any other abscess. Local applications of soothing lotions or ointments are usually all that is necessary.

Mastitis Adolescentium.—A similar condition is observed now and then in boys and girls at puberty.

Chronic Interstitial Mastitis.—Rarely there has been observed a very chronic form of inflammation which manifests itself at about the time of the menopause or later. This is characterized by atrophy and firm fibrous infiltration of the gland and overlying fat. It resembles very closely the atrophic form of scirrhous cancer and it is not unlikely that mistakes in diagnosis have been made. In this condition, which is certainly extremely rare, the main point is the diagnosis. In case of doubt, excise as in carcinoma. Palliative treatment is of little avail.

Lactation Mastitis.—This is by far the most common variety, occurring in 6 per cent. of all lactating women (Guleke). It is found in all grades, from a simple retention of secretion, "the caked breast," to intense and even fatal suppuration.

Stagnation Mastitis ("Caked Breast").—This form is generally met with toward the end of pregnancy and in the early part of lactation. It involves a portion of the gland only, having its origin usually in a single lobe which becomes indurated and knotted. There is tenderness, with little pain. Constitutional disturbances are slight. Retention of the secretions seems to be the primary cause of the trouble. Prompt recovery usually follows the institution of measures directed toward the relief of this retention, such as a properly applied supporting and compression bandage, the emptying of the breast by skilful massage, or the use of the breast-pump. If resolution is not brought about speedily, suppuration takes place and we have the next and by far the most common form, namely—

Pyogenic Mastitis.—This variety is due to the presence of pyogenic organisms in the tissues of the breast and is almost invariably accompanied by suppuration. In the great majority of instances this form of mastitis is found in the lactating breast, but other specific infections of the non-lactating breast have been observed—*e. g.*, those occurring in the course of typhoid fever, tuberculosis, osteomyelitis, specific or otherwise, of the underlying ribs, traumatism, etc. The usual avenue of infection is through the nipple and ducts, but the infection may spread from the surrounding structures, *e. g.*, the subareolar space and the sebaceous and other glands of that vicinity.

The process may extend to the deeper structures of the breast, in fact, it may involve and even destroy the entire gland or, in favorable cases, it may resolve and leave the gland structure and function unimpaired.

It is accompanied by the usual signs of suppuration, local and constitutional. The process tends toward central softening and spontaneous opening, but it should never be allowed to reach this stage.

Treatment.—The value of early and free incision as a conservative measure cannot be overestimated. The tendency is always toward doing too little, and so the infective process travels from one lobe to another unrelieved, until the whole gland may be practically destroyed and the patient's life jeopardized. Recently the method of treatment

of acute infection by hyperemia, as suggested by Bier, has been applied to this condition with excellent results.

Incisions into breast tissue should always radiate from the nipple like the spokes from the hub of a wheel, thus avoiding cutting across the ducts. It is a good plan, where the abscess is a large one, to make one or more incisions over the fluctuating area and another at the most dependent portion. Drains should then be passed through, connecting the various openings. This is especially indicated in those large abscess cavities where the pus is between the gland and the pectoral muscle (*submammary abscess*). The finger should be introduced into the various incisions, the trabeculæ broken down, and the pus cavities made into one large one. Upon the promptness and thoroughness with which the original operation is done depends in large measure the subsequent degree of usefulness of the gland.

Unresolved areas of chronic inflammation persisting for long periods of time are prone to cancerous degeneration and should always be regarded with suspicion.

After incision, compression and support are always grateful to the patient and are of undoubted therapeutic value.

The breasts during pregnancy and lactation are particularly immune to disease. Infection is the single exception to this rule. Obscure affections of the breast occurring during the period of functional activity are, *prima facie*, inflammatory in character. Exceptions to this rule are, of course, observed at rare intervals. Carcinoma was observed to develop during lactation in but 2 per cent. of cases in Halsted's clinic. Deep-seated infections in the parenchyma of the breast occurring soon after parturition may be accompanied by few if any local symptoms, while the constitutional disturbance, fever, chills, etc., may be great.

Postmammary Abscess.—When mastitis goes on to suppuration the abscess is found, as a rule, pointing anteriorly in the central zone of the gland. Occasionally, however, it may point and rupture posteriorly, the pus presenting itself in the submammary tissues.

Abscesses may occur behind the breast as a result of injury or extension of an inflammatory process from neighboring structures, *e. g.*, the extension of an empyema through the chest wall, osteomyelitis of the ribs and cartilages, tuberculosis of the ribs, typhoid periostitis, etc.

Treatment.—In opening a postmammary abscess the incision should be made at the lower edge of the breast and free drainage established there. If the abscess originates in the chest wall, as the result of tuberculosis, typhoid fever, etc., appropriate treatment for that particular affection should be carried out.

Tuberculous Mastitis.—(See Vol. I., p. 652.)

Syphilitic Mastitis.—*Syphilis of the breast* (see Vol. I., p. 715).

Actinomycosis.—This is one of the rarest diseases of the breast, but has been observed in a few cases. It may occur as a primary or secondary affection. It is most often mistaken for tuberculosis. The diagnosis is established by finding the actinomyces in the discharge from the sinuses.

Thorough extirpation of the infected tissues, together with the administration of iodid of potash and sulphate of copper, are to be recommended.

WOUNDS AND CONTUSIONS OF THE BREAST.

Injuries to the tissues of the mammary gland heal quite as readily as those of other structures, as is shown by the rapid repair observed in wounds inflicted by the surgeon's knife.

Contusions may be followed by more serious consequences. The effusion may become infected and be followed by mastitis and abscess formation. There is a deeply rooted conviction in the minds of the laity as well as of many medical men (which belief is hardly substantiated by the facts) that trauma of this sort not infrequently predisposes to the subsequent development of cancer. The treatment is the same as for contusions elsewhere, treating the sinus as we would any other discharging wound.

MILK FISTULAE.

Chronic sinuses, which discharge milk in larger or smaller quantities, have been observed as the result of trauma inflicted during lactation, such as stab wounds, contusions, abscesses, etc. These are best treated by terminating the lactation as speedily as possible, combined with the usual surgical measures.

FOREIGN BODIES.

I have recently removed from the left breast of a young woman the pointed half of a broken needle, which she asserted had been swallowed by her some three years previously and forgotten.

Other foreign bodies, such as sequestra of bone, splinters of wood, etc., have been removed from the substance of the breast.

BENIGN TUMORS.

The general characteristics distinguishing a benign from a malignant tumor are as follows: A benign tumor is encapsulated, freely movable on the surrounding tissues, not associated with any changes in the skin, such as retraction or dimpling, nor atrophy of the overlying fat, and no metastases. They are more apt to be multiple than the malignant growths and pain is a more prominent feature. They occur at an earlier age than the malignant growths and they are apt to be of rather softer consistency. A discharge from the nipple, unless it is bloody, is significant rather of a benign swelling. The following are the most common varieties.

Angioma, Nævus.—The breast and its overlying integument may be the seat of vascular tumors involving a part or, in very rare instances, the whole of the mammary gland. These affections are relatively rare, and when they do occur manifest themselves, as a rule, at or soon after birth, presenting the characteristic appearance of similar tumors elsewhere.

They are usually of small size, involving only a small portion of the breast tissue and the skin over it.

Diagnosis.—There is nothing especially difficult about the diagnosis unless it may be in the intraglandular type where the swelling is deeply placed. The color of the skin together with the compressibility of the tumor and its immediate return to its former size upon withdrawing the pressure are the most characteristic signs.

The complete extirpation of the tumor is the most satisfactory treatment in the end.

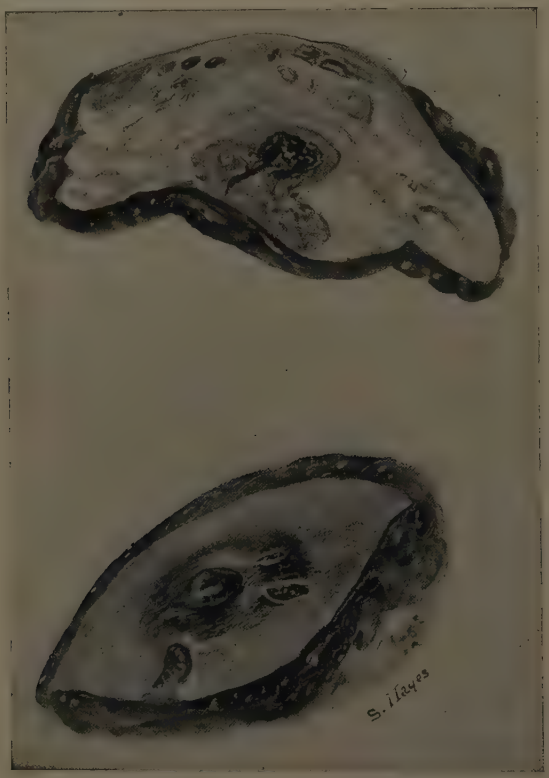

FIG. 331.—TUBERCULOSIS OF BREAST.

Papillomata, moles, and other excrescences from the skin covering the nipples and breasts have been reported from time to time, but their presence in this locality is purely adventitious and of no significance.

Lipoma of the breast proper is one of the rarest of tumors. Hypertrophy of the fatty capsule or a great increase in the fat surrounding the breast in senile and other conditions are very frequently met with and should be differentiated from true lipoma.

The same physical characteristics are found present in lipoma of the breast as are observed elsewhere—*e. g.*, lobulation, soft semifluctuant consistency, and rather loose attachment to the surrounding structures.

Mixed Tumors of the Breast.—In the mammary gland at rare intervals have been observed tumors containing structures not found in the normal breast. These are analogous to and resemble very closely the mixed tumors of the parotid. Histologically their structure is very diverse and peculiar. The origin of these tumors is very probably from embryonic intraglandular inclusions. They are clinically benign, as they are invariably encapsulated and resemble very closely the common benign tumors of the breast.

A correct diagnosis is almost impossible without a histologic examination. They may occur at any time from puberty to old age. Amputation of the entire breast, but not of the muscles or axillary glands, is to be advised in every case where the tumor has shown any signs of special activity.

Calcification of the Breast.—A unique case of calcification of the walls of an abscess cavity in the breast of a young negress has

FIG. 332.—FIBRO-ADENOMA MISTAKEN FOR UNILATERAL HYPERTROPHY.

recently been reported by Thayer. The abscess developed in the course of a severe typhoid fever, subsequent to the administration of large doses of calcium lactate by the mouth, and the injection of 500 cc. of a 1 per cent. calcium chlorid solution into the submammary tissues. The abscess cavity was incised and packed with iodoform gauze. The subsequent deposition of calcium salts in the walls of the abscess was thought to be due to the chemical action of the iodin in the iodoform gauze combining with the calcium in the tissues. Calcification has been observed in the walls of simple cysts of long duration and also in old adenofibromata.

Fibro-adenoma.—Although a few cases of so-called pure fibromata and adenomata of the breast have been recorded in literature, accompanied in a few instances by the report of the microscopic findings,

still their existence has been doubted by many competent authorities, notably Billroth and Schimmelbusch.

It is probable that in every instance there is an increase in both the fibrous and glandular elements, now one predominating and again the other, but never the one to the total exclusion of the other. It is very important in the examination of these tumors to study the whole tumor, center as well as periphery, for it not infrequently happens that the different parts of the same tumor show the fibrous and glandular elements present in varying proportions. These macroscopic and microscopic conditions give rise to certain characteristic clinical phenomena, and to these differing pictures have been given from time to time different names and different names by different authors for the same condition. Hence there has arisen a great multiplicity and

FIG. 333.—FIBRO-ADENOMA OF THE BREAST.

confusion of terms in designating the various benign tumors of fibrous origin.

As a matter of fact these sharp differentiations interest the pathologist far more than they do the clinician. The main consideration should always be the proper decision of the question as to the *benignancy* or *malignancy* of the particular tumor under consideration; and toward this end all the energies of the clinician should be directed. It is extremely difficult to make a satisfactory classification of these growths, but, in general, they may be divided into two main classes: (*a*) Those in which the fibrous stroma elements predominate, and (*b*) those in which the glandular epithelial elements are in excess. Of these two classes, those tumors comprising the former, the fibrous variety, are in the majority. Indeed, next to carcinoma, they are found more frequently than any other tumor of the breast.

Intracanalicular Myxoma.—The particular structure forming the basis of this neoplasm is that peculiarly hyaline myxomatous

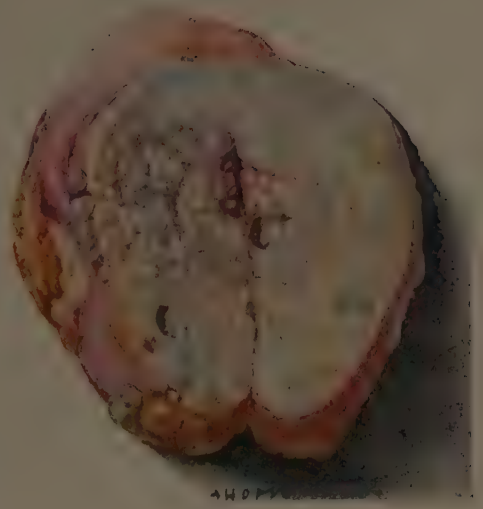

FIG. 1.—CYSTIC ADENOMA OF BREAST (Bloodgood).

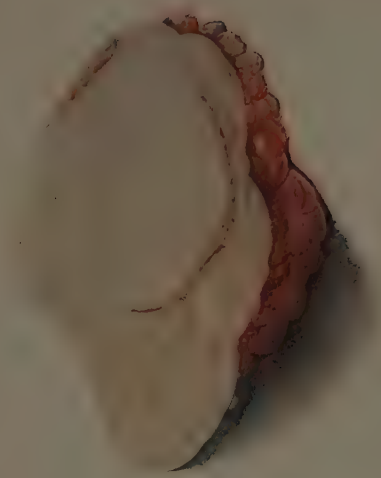

FIG. 2.—INTRACANALICULAR MYXOMA.

PLATE V.

fibrous tissue which immediately surrounds the ducts and acini of the glands. It is distinctively a tumor of the young breast, occurring most often in women between the ages of fifteen and thirty. It is not infrequently multiple and may be bilateral. The tumors are of slow or intermittent growth and, as a rule, painless. More or less well-marked tenderness has been complained of during or immediately preceding menstruation.

They manifest themselves clinically as firm nodules, encapsulated, not very freely movable in the surrounding breast tissue, and not attached to the skin. They are irregular in outline, with here and there rounded bosses elevated above the surface of the tumor. There is an indistinct sense of elasticity, amounting in some cases, usually in the larger tumors, to a well-defined sense of fluctuation.

The tumor may remain unchanged for a longer or shorter period, sometimes for years, or it grows slowly or intermittently. Sudden and rapid growth in the tumor, particularly in those occurring in women above forty, should always be regarded with suspicion. Sarcomatous changes begin in this way. Retraction of the skin or nipple is not present, swelling of the lymph-glands is never observed unless as a coincidence. Redness and ulceration of the skin are only observed in tumors of large size and long standing.

Pathology.—On section these tumors are found to be well encapsulated. The cut surface presents a whitish rather glistening lobulated appearance. The individual lobules are slightly elevated above the surface. Clefts and spaces containing a little clear or cloudy fluid can readily be seen, forming here and there slight dilatations in the nature of cysts (Plate V.).

Microscopically these spaces are found to be lined with epithelium which may show proliferation and adenocystic changes. The epithelial lining of the acini and ducts, however, almost always remains of one layer, a distinguishing characteristic from carcinoma.

The dilated epithelial-lined ducts and spaces are seen to have here and there projecting into them papillomatous growths of myxomatous periductal connective tissue which are the especially characteristic feature of the histologic picture, and which give to it its name.

Treatment.—"Any lump in any woman's breast is better out than in" is a surgical axiom which applies to benign as well as to malignant conditions. Excision is the safest course to pursue in every instance. Intracanalicular myxomata are, in their early stages, both clinically and pathologically benign. Unfortunately, however, a certain small percentage of them tend to become malignant. It is to guard against the possibility of this calamity that the seemingly too harsh and radical operative measures are to be recommended.

In the earlier cases where the growth is small, excision of the tumor alone is all that is necessary. Where the tumor is larger, has markedly increased in size recently, involving a considerable portion or the whole of the mammary gland, it is advisable to remove the entire gland, and in late cases, the pectoralis major muscle. It is an interesting fact

that where the tumors are multiple there seems to be less tendency toward malignancy than in the case of single tumors, and hence the treatment may be with safety correspondingly less radical (Bloodgood).

Adenofibroma.—This tumor, like the intracanalicular myxoma, is found in the young breast—*i. e.*, between the ages of fifteen and thirty. It is somewhat rarer than the intracanalicular myxoma. On palpation the growth is smooth, not presenting any bosses. It is rather firm and elastic. It is usually single and painless. As a rule it is small, but occasionally may be so large as to present the appearance of a true unilateral hypertrophy, for which it has been mistaken.

Pathology.—The growth has a definite capsule and presents slight lobulation. On section the surface looks like that of a fibroma.

Microscopically the growth is composed chiefly of dense fibrous tissue and has scattered through it slit-like ducts and acini, lined with proliferating epithelium.

Treatment.—Excision of the tumor with its capsule is to be invariably recommended.

Cystic Adenoma.—This is one of the rarer affections. It may be considered a type of intracanalicular myxoma in which the epithelial elements predominate.

These tumors occur in young women, are of slow growth and long duration. They are usually of small size, lobulated, hard, and freely movable under the skin. There is no discharge from the nipple.

Pathology.—They are definitely encapsulated and lobular, and cysts can frequently be seen shining through the capsule. On cutting into such a growth numbers of cysts of various sizes are seen, surrounded by hypertrophied glandular tissue resembling the lactating breast. Some of the cysts, especially the larger ones, contain papillary ingrowths. Keibel states that about 10 per cent. of these growths undergo malignant degeneration (Plate V.).

Treatment.—Excision of the growth is all that is necessary in most cases.

CYSTS.

Cysts of the mammary gland may be classified as follows:

Retention cysts (see Galactocele).

Simple cysts.

Cysts with intracystic papillomatous growths.

Dermoid cysts.

Hydatid cysts.

Cancer cysts.

Cysts developing in malignant growths.

Simple Cysts.—As a rule this form of cyst is found in connection with abnormal involution of the breast and is most common in women after the age of forty.

They occur either singly or as multiple tumors, involving one or both breasts. These tumors are more common in breasts which have never lactated. They compose about 50 per cent. of all tumors in such breasts.

Symptoms.—Pain is usually a prominent symptom, especially if the tumor is of rapid growth. There may be a discharge from the nipple, but this is rare. If the cyst is near the surface, it can usually be made out as such on palpation, but when it is situated deeply in the breast tissue the only thing to be made out is an area of induration. Fluctuation may be felt in the superficial cysts, but often they are very tense and hard and give the impression of a solid growth. The outline is round and regular and the surface smooth. There is no atrophy of the subcutaneous fat and no retraction of the nipple unless the cyst has become inflamed, in which case retraction of the nipple may be present.

Pathology.—Macroscopically these cysts are of a bluish color, and one generally finds other smaller ones scattered throughout the breast.

Microscopically the thin walls of the larger cysts are composed of fibrous tissue. Their surface is smooth and glistening. The smaller cysts are lined by one or two layers of low columnar epithelium. The ducts are found to be dilated and show epithelial hyperplasia. The breast tissue surrounding the cysts presents areas of parenchymatous hypertrophy. Relative to carcinoma, this cyst formation in connection with senile parenchymatous hypertrophy is followed in a large percentage of cases by adenocarcinoma.

Treatment.—Single cysts may be excised together with an area of breast tissue if there is no evidence of infiltration in the wall and the contents are not bloody. If multiple cysts are present it is perhaps better to remove the entire gland, in view of the tendency toward malignant degeneration. Simple tapping of the larger cysts has been advocated by a number of surgeons, notably Abbe. Cures by this method have been recorded. It is applicable, however, only in the case of large cysts, and McGraw and others have reported cases in which aspiration of cysts has been followed by the development of cancer.

In doubtful cases no rational objection can be raised to a properly executed exploratory incision.

Warren has elaborated a method of plastic resection of the mammary gland which possesses many commendatory features.

Through the so-called "Thomas" incision he removes a V-shaped portion of the gland containing the cyst or tumor and makes, where necessary, exploratory radiating incisions through the remainder of the gland substance. Through a somewhat exaggerated "Thomas" incision the lower border of the pectoralis muscle is freely exposed and the dissection is carried through the loose connective tissue in which the mammary gland lies.

The breast is next reflected upward and inward, exposing the posterior surface of the gland. If cysts are present they are readily observed and removed through a V-shaped incision without opening the cysts. The apex of the V lies directly under the nipple. Radiating from this point, incisions can be carried into the gland tissue, exposing and bisecting all small cysts. After arresting the hemorrhage from the larger vessels, the V-shaped defect is repaired by two rows of catgut sutures, one along its anterior border and one along the posterior.

The glands should next be anchored to the subjacent pectoral muscle at its outer edge, and still another row of sutures is advisable to hold together the deep layers of the superficial fascia before closing the outer edges of the wound.

The dressing should be applied in order to produce lateral compression of the two hemispheres. Warren has devised a special bandage for this purpose.

This incision is applicable for exploration of the breast in all cases where benign tumors are present.

Forcible massage, which has from time to time been recommended for the removal of cystic tumors of the breast, while undoubtedly efficacious in some cases, has in it too many possibilities of evil for general adoption.

Cysts with Intracystic Papillomatous Growths.—This form of cyst is much rarer than the simple cyst, and clinically differs little from it.

In the majority of cases these patients consult the physician on account of a discharge from the nipple. This is the characteristic symptom of this form of growth and may be slight in amount or quite profuse. It is serous in character, generally bloody or blood stained. On palpation of such a breast one finds near the nipple a mass which usually can be made out to be cystic, at times elongated toward the nipple.

These growths have been known to exist for various lengths of time, from a few months to ten to fifteen years. Ill has observed spontaneous disappearance in some cases.

Although these cysts may remain benign for long periods, they have a tendency to become malignant, as shown by the fact that about 50 per cent. of those observed at the Johns Hopkins Hospital had undergone carcinomatous changes.

Pathologically one finds a cyst with a papillomatous ingrowth from the wall. It may be small or it may entirely fill the cyst. The fluid is almost always bloody.

Microscopically the papillomata are found to be composed of outgrowths of connective tissue surrounded by one or more layers of proliferating epithelium of the ductal type. Infiltration of the surrounding breast tissue is observed only after carcinomatous changes have taken place.

Treatment.—The entire breast should be removed in all cases. If the base of the papillary growth is indurated with evidence of infiltration of the surrounding breast tissue, then the complete operation for cancer should be done.

Dermoid Cysts.—It has been questioned by some authors whether any undoubted case of dermoid cyst of the breast has ever been observed. Williams states that while they are exceedingly rare, a few cases can be collected from the literature.

Treatment.—Here, as elsewhere, the cyst should be thoroughly extirpated, if possible, without rupturing the sac, since any vestige of

PLATE VI.

Intracystic Papilloma, Already Become Malignant, with Involvement of Axillary Glands.

the sac wall left behind may form the nucleus of a new dermoid. If small, the cyst alone should be excised; if large, it is better to remove the entire breast.

Hydatid Disease of the Breast.—This is one of the rarest affections met with in the breast. Le Conte, in reporting a single case which had come under his observation in 1901, could find no other case reported in this country.

Owing to the great rarity of the disease the diagnosis is rarely made before removal. In its incipiency in young women it naturally suggests a benign tumor. In its later stages, particularly when observed in older women, owing to its hardness, irregularity in outline, and the tendency to involve the skin, it might easily be mistaken for carcinoma.

Treatment.—If seen early, excision of the tumor alone; if later, excision of the breast is to be advised.

Cancer Cysts.—These will be discussed under Cancer of the Breast.

SARCOMA.

Sarcoma must be classed as one of the rarer affections of the breast. Indeed, the immunity from sarcomatous affections enjoyed by the mammary gland is remarkable in view of its histologic structure and great functional changes. The sarcoma may have its origin in the intralobular hyaline connective tissue, or in the denser interstitial fibrous stroma surrounding the lobules of the gland, or it may be a metastasis from a distant primary growth, *e. g.*, the ovary, tonsil, etc. Instances of all of the various cellular varieties of sarcoma, *e. g.*, spindle, round, giant, melanotic, etc., have been reported, but, with the exception of the first named, they are of extreme rarity.

The commonest variety of all, comprising from 2 to 3 per cent. of all malignant and 80 per cent. of all sarcomatous diseases of the breast, is that form which develops from the intralobular or periductal fibrous tissue, a later stage of intracanalicular myxoma.

Not all large intracanalicular myxomata become sarcomatous, but after they have reached a certain size the tendency toward malignancy is marked. The fact that so large a number (20 per cent.) of those involving the whole breast contain areas of sarcoma, should make one regard with suspicion all tumors of this character which have attained considerable size.

Clinically, these tumors are at first always benign. For this reason the diagnosis is extremely difficult and in many cases impossible before removal. The tumor is encapsulated, freely movable on the surrounding structure, skin not attached, nipple not retracted. Pain and tenderness are not pronounced, but may be present periodically. The tumor is usually unilateral and single, but may be bilateral and multiple.

The smaller tumors are firm, rather irregular in outline, with bosses here and there. Later there is always noticed a tendency toward cystic degeneration; this characteristic has given to them the name of cystosarcoma. The process involves the entire gland, and in neglected cases

may invade the underlying pectoral fascia and muscle. In advanced cases a red, tense, shiny condition of the overlying skin develops. The skin itself becomes adherent and may ulcerate, giving rise to a foul, fungating, ulcerating mass. The neighboring veins increase in size and prominence. The axillary glands may become enlarged and palpable in this stage, but rarely ever show metastases, the enlargement being due to inflammatory hyperplasia. When metastases do occur, they are more often observed in the internal organs and skin. There may or may not be discharge from the nipple.

Diagnosis.—In the earlier stages it is impossible to make a diagnosis with any degree of certainty. Intracanalicular myxoma, adenofibroma, cysts, and in older women even carcinoma must be differentiated. The age of the patient, the character and location of the tumor, whether single or multiple, the presence of fluctuating areas, absence of glandular involvement, all point strongly toward the sarcomatous nature of the growth.

On fresh section and microscopically they show practically the same structure as the intracanalicular myxoma, with here and there cysts, sometimes of considerable size, typic myxomatous areas, and also areas of spindle and round-celled sarcoma.

Metastatic sarcomatous nodules have been observed in the breast from primary foci in distant organs, *e. g.*, ovary and tonsil. They showed the same characteristics exhibited by sarcomata elsewhere.

Treatment.—The complete removal of the breast and greater pectoral muscle should be practised in every case if one would be on the safe side. When the axillary glands are found to be involved, it is usually too late to obtain a cure, but their removal will probably tend to delay the progress of the disease and possibly, in rare instances, bring about a cure.

In the case of small sarcomata the excision of the tumor with a good margin of healthy breast tissue may suffice, but where any doubt exists, the complete operation should be employed. One should never temporize nor compromise with malignant growths. The final results of operation for sarcoma of the breast are more favorable according to Poulson than after cancer; 75 per cent. of the cases are free from recurrence after five years.

CARCINOMA.

By far the most important problems to be considered in the surgery of the breast are the diagnosis and treatment of cancer. In the examination of every patient with a lump in the breast the first question the surgeon should ask himself should be, "Is this cancer?" Many things are to be considered in order to arrive at a correct answer to this all-important question, but in the end a positive diagnosis is generally possible. The diagnosis of cancer having been established, the next question of importance is, "What treatment shall be employed?"

Frequency.—It is now generally accepted that at least 8 per cent. of all mammary neoplasms are carcinomatous. Statistics based upon

the United States census of 1900 would indicate that cancer of the breast caused over 3500 deaths during that year (McConnell). This estimate probably falls nearer the lower than the upper limit of error.

Etiology.—Since the cause of cancer remains unknown, it is possible at this time to point out only those factors which are generally assumed to bear some more or less intimate relationship to its development.

Age and Sex.—Approximately, two-thirds of all cases develop between the fortieth and sixtieth years, being more frequent (21 per cent.) between forty-six and fifty-one than during any other five years, with the average age of onset at fifty-one. It becomes progressively more infrequent thereafter, virtually ceasing to appear at the age of eighty. Slightly over 1 per cent. occur in males.

Sexual Condition.—Only $27\frac{5}{10}$ per cent. of the cases occur before the menopause. In the others the average time from this period to the onset of the tumor is five and two-tenths years.

It has been estimated that from 50 to 80 per cent. are married, of these 80 to 90 per cent. have borne children, and 70 to 95 per cent. have nursed them. Cancer of the breast is relatively common in multiparæ, 20 per cent. having had six or more children.

Heredity.—A family history of cancer has been reported in from 3 to 33 per cent. of the cases, average 19 per cent. In a few well-marked instances there is indisputably strong family predisposition to the development of cancer, and at times with a predilection for the breast. In general, however, it seems justifiable to assume that this relationship is quite as casual as causal. Thus Jennings found a family history of cancer in 1 out of 9 cases where the disease in the breast was malignant, and 1 out of 7 where it was benign.

Traumatism.—From 3 to 39 per cent. (average 14 per cent.) of the patients attributed their tumors to some injury. A determination of this relationship is usually difficult and often impossible. The observers who have made a point of eliminating those cases in which injury appeared to have been only incidental, obtained percentages much below those actually given. Gilliam obtained a history of trauma in $13\frac{4}{10}$ per cent, but in only $\frac{1}{4}$ of 1 per cent. did the tumor arise in the resulting cicatrix. It is probable that an injury is far more apt to attract the attention to a pre-existing growth than it is to be the exciting cause.

Mastitis.—Under this heading come two main types: (1) The infectious form, associated with lactation, and (2) the involution form, associated with the menopause.

(1) Acute or chronic suppurative mastitis is stated by Guleke to occur in 6 per cent. of all women during the puerperium. It is said to have occurred in 22 per cent. of women with mammary cancer, but Rosenstein found it had involved the affected side in but 8 per cent. of his cases. If, however, allowance is made for the fact that a considerable proportion of the women with cancer of the breast have never lactated, the relative frequency becomes much larger.

The conclusion seems abundantly justified that this affection exerts some more or less direct influence in the etiology, but it is probably only in those cases where the areas of induration persist.

(2) The involution form is to some extent a normal concomitant of the menopause. Coming at the cancer age, it is commonly associated with malignant disease, and at times is directly causative, as observed by Greenough and Hartwell, Bloodgood, and others.

Benign Tumors.—Repeated clinical observations have shown that a tumor, apparently possessing all of the attributes of benignancy and frequently of years' duration, may suddenly, with or without demonstrable cause, assume malignant characteristics.

Pathologic investigation has demonstrated that no tumor of the breast so essentially concerns the connective tissue alone that the growth of the epithelium remains uninfluenced, and once having become abnormal, it may undergo malignant degeneration at any time. This is exceedingly rare in the periductal or intracanalicular fibromatous forms (though here sarcomatous metamorphosis is less infrequent). In the adenomatous types it is more frequent, and in the intracystic papillary varieties it occurs in nearly 50 per cent. of the cases.

Pathology.—The fundamental importance of this subject cannot be overestimated, for not one essential advance has been made in the radical treatment of cancer of the breast that is not directly traceable to the laboratory. In spite of the great advances already made, much remains to be learned aside from the all-important question of etiology. For example, the relative malignancy of different tumors and their prognosis is still largely a matter of conjecture.

General Considerations.—Carcinoma mammæ is here regarded as arising from the glandular epithelium of normal, accessory, or paramammary tissue. The disease is at its inception perfectly localized. No assumption can be made as to how long this limitation persists, hence, so far as our knowledge goes, no carcinoma is too young not to have lost this restriction—*i. e.*, to have already spread from its point of origin.

The malignant nature of the disease is manifested by the invasion of surrounding tissues through direct extension or growth by continuity, and by transplantation or metastasis of tumor cells to more remote tissues carried there through the blood or lymph streams as emboli.

Principles of Lymphatic Involvement.—It is universally recognized that cancer spreads almost entirely through the lymphatics, and that the lymph channels lead through lymph glands, which have a filter-like function.

Oelsner has shown that certain lymph channels drain certain areas and terminate in certain glands. These areas are not distinct, but freely anastomose with similar adjacent areas, particularly through the finer channels or radicles at their periphery. Should the efferent lymph channels of such an area become occluded, it would naturally follow that there will be attempted the formation of a compensatory circulation through the nearest area in anastomotic contact and pos-

sessing a free efferent vessel. Thus, the lymph collecting distally to the point of occlusion would come to pass in a direction opposite to normal, backward from larger to smaller channels, through the anastomosing networks of the radicles of adjacent areas, and finally flow again toward the center through unusual channels and glands. Every lymph channel is thus provided practically with a filter at each end, proximally the normal lymph gland, distally the network of lymph radicles at the periphery. Such filters do not always intercept embolic cancer cells. They frequently escape this first set of obstructions to be arrested by others beyond.

This conception of the arrangement and behavior of the lymphatics will aid greatly in understanding the irregularities of metastatic distribution observed clinically in the progress of the disease.

Anatomic Considerations as to the Lymphatics.—Before attempting to describe the bearing of the pathologic upon the clinical aspects of the disease, a summary of a few anatomic peculiarities will not be out of place:

Breast.—The usual conception that the mammary gland is sharply defined has been shown to be entirely erroneous by Heidenhain and, again more recently, by Oelsner. There are extensions of parenchyma outward along the ligaments of Cooper, which may reach almost to the papillary processes of the skin and downward to or even into the pectoralis major muscle, and others projecting into the fat.

Over the inner and lower quadrant the line of demarcation from the fat is fairly sharp, and the gland is more closely adherent to the deeper fascia, being bound down by fibrous bundles, the submammary ligaments. Cancer at this location is usually destined to early and deep adhesions.

Since cancer may begin in any part of the breast and since no part of a breast harboring a cancer may not be involved by the time the tumor is recognizable, it follows from the topography of the mammary parenchyma that the lymphatics draining a very extensive mass of tissue are to be suspected of already containing malignant deposits. These include the lymphatics of more than the overlying skin, of the surrounding subcutaneous fat, of all the breast tissue, and of the underlying pectoral fascia and muscles.

Lymphatics.—The following summary is based upon the experimental and pathologic observations of several investigators:

Skin.—The lymphatics of the cutis are made up of two superimposed networks. From each arise efferent trunks, leading to the axilla, which, however, occasionally re-approach the skin. (Oelsner thinks this may explain some skin metastases.) There is free anastomosis between the two body halves in both the deep and superficial networks. From the upper mesial aspect of the chest lymphatics lead upward in front of the clavicle to supraclavicular glands.

Fat.—It is physically almost impossible to inject the lymph vessels in this tissue, and it is assumed that they accompany the corresponding blood-vessels to enter the axilla and the thorax.

Breast.—After arising in the substance of the gland, the lymphatics run toward its surface, here being fused into the efferent channels. The axillary are the main vessels, the more superficial accompanying the cutaneous lymphatics, the deeper lying upon the pectoral fascia. Other constant but smaller efferent channels leave the lower surface of the breast, follow the perforating branches of the internal mammary artery, and empty into the glands of the anterior mediastinum, and still others follow the intercostals toward the spine.

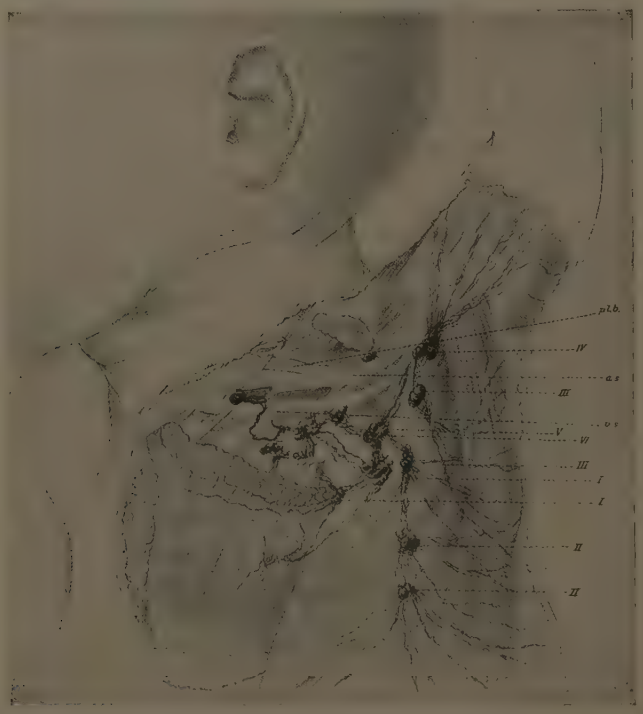

FIG. 334.—LYMPHATICS OF THE AXILLA. (Oelsner.)

I., Glandul. lymph. thor. ant.; *II.*, glandul. lymph. thor. inf.; *III.*, glandul. lymph. thor. post. s. subscap.; *IV.*, glandul. lymph. thor. sup. brachial; *V.*, glandul. lymph. thor. intermedial; *VI.*, glandul. lymph. thor. subpect. et subclav.; *v. s.*, vena subclavia; *a. s.*, arteria subclavia; *pl. b.*, plexus brachialis.

A fairly constant and most important lymph vessel runs from the base of the breast, perforates the pectoralis major, extending between it and the minor and upward along the chest wall below the attachment of the major muscle to enter the anterior mediastinum through the second intercostal space.

Muscle.—One set of lymphatics runs parallel to the muscular fibers toward the sternum and close to its margin they perforate the intercostal spaces to enter the mediastinal glands. Ludwig, Schweigger, Seidel, and Rotter believe that the flow of lymph in the most superficial part of the muscle is toward the fascia. The lymphatics of the clavicular portion empty into retropectoral glands, the manubrial attachment

drains anterior to the clavicle into supraclavicular glands. The muscular and deep mammary branches probably drain the pectoral fascia.

Glands.—These may be divided more or less arbitrarily into groups, but without much practical advantage. The real therapeutic importance lies in their complete removal. They extend the whole length of the large blood-vessels, in close relation to the vein, from the base to the apex of the axilla; posteriorly in the cellular tissue between the anterior surface of the scapula and the serratus magnus muscle; and mesially along the wall of the thorax beneath the attachment of the pectoralis major muscle close to the superior thoracic. Chains of glands also accompany the internal mammary perforating branches, and others lie between the pectoralis major and minor. Aberrant glands may occur in many places, but are usually of less operative significance. The glands in the posterior cervical triangle are always liable to be involved from below.

Varieties of Cancer.—Thus far consideration has been given to cancer of the breast in general. Each variety has characteristics common to all, and each may eventually progress virtually as any other in its effects upon the individual. As far as treatment is concerned, a cancer is a cancer, and the same theory is applicable to every case, but the results of this treatment vary somewhat with the different forms. In other words, the prognosis varies with the malignancy of the tumor, other conditions being equal.

Mammary cancers are divisible into two main groups: Primary (common) and secondary (rare).

Classification.—Pathologists have subdivided the primary cancers into: (1) The ordinary glandular carcinomoa (scirrhus); (2) adenocarcinoma; (3) colloid carcinoma; (4) cancer cysts; (5) Paget's disease.

(1) The **glandular carcinomas** are characterized by the presence of irregular clefts or spaces in the connective-tissue framework, which are more or less completely filled with epithelial cells having no definite arrangement.

According to the relative proportion of the amounts of connective tissue and epithelium present, these tumors are again subdivided into: (*a*) Scirrhus carcinoma, where the connective tissue is in excess; (*b*) carcinoma simplex, where there is relative equality; (*c*) medullary carcinoma, where the epithelium exceeds the stroma in amount.

(*a*) *Scirrhus* (17 to 56 per cent.).—This form is usually considered by far the most frequent and at the same time relatively less malignant, because of its comparatively slow growth and histologic characteristics. In all probability this is true particularly in the very pronounced types, the so-called atrophic scirrhus, where there is an excessive preponderance of connective tissue and the resulting contraction so extensive as to produce a shrinkage rather than a tumefaction. Practically, however, this variety does not give the satisfactory therapeutic results that might be expected.

As to the treatment of this condition, early cases, of course, should be submitted to the radical operation, as in other forms of carcinoma, but where the disease has progressed to the stage of fixation to the chest wall, and where ulceration is not yet present, it is perhaps, in selected cases, advisable to defer operation altogether or until it is rendered necessary in order to remove a foul-smelling sloughing mass. In other words, since the progress of this particular form of carcinoma is so slow and the discomfort to the patient comparatively slight, and the hope of cure from the operation so remote, it is hardly advisable to practise the same routine as in other forms of carcinoma. Such cases may be erroneously classified as cures when they appear free from the disease for three or more years. A fatal termination may be delayed for twenty years or longer.

FIG. 335.—INFILTRATING SCIRRHUS, SHOWING "DERMATITIS CARCINOSA."

These tumors may arise anywhere in the breast or nipple, and no special factor has been shown to be concerned in their causation. Infrequently a scirrhous tumor has resulted from the malignant metamorphosis of a benign tumor (Clopton), of chronic cystic mastitis (Ellis), or of Paget's disease.

(*b*) *Carcinoma simplex* (15 to 58 per cent.) includes an indefinite group of tumors standing midway between the preceding and succeeding types in their various characteristics.

(*c*) *Medullary Carcinoma* (*Encephaloid*) (2 to 4 per cent.).—In this class fall what are generally regarded as among the most malignant tumors, both from the standpoint of histopathology and as apparently confirmed by the limited reports of clinical observations. This, however, has not been the experience in the Johns Hopkins clinic.

(2) **Adenocarcinoma** (3 to 5 per cent.).—Under this heading are included those forms which tend to reproduce glandular structures (alveoli) in the malignant tissue. As a class they are not very malignant, even when they grow rapidly and to considerable size, with a manifest tendency toward ulceration. Especially is this true in cases where there is an apparent constriction at the base of the tumor, as first noted by Halsted, who places the villous cancer of the French and the duct cancer of the English in this category. No other cancer seems to spring so frequently from chronic cystic mastitis (senile parenchymatous hypertrophy) or from benign tumors, particularly the cystic, as do these adenomatous forms. It is, however, frequently noted that there

is a tendency for this adenomatous formation to disappear as the growth progresses and to be replaced by the ordinary carcinomatous structures.

FIG. 336.—MEDULLARY CARCINOMA.

(3) **Colloid Carcinoma** ($\frac{1}{3}$ to 3 per cent.).—In this subdivision is placed a form of degeneration rather than a distinct type of cancer. It is characterized by the deposition of colloid (mucin) between the

FIG. 337.—MEDULLARY CARCINOMA OF THE BREAST.

epithelial cells and the stroma (Simmonds, Eve, Lange). The encapsulation of the epithelium is more or less complete, and the resultant increased intra-alveolar pressure produces degenerative changes in the epithelial cells, two factors which are supposed to explain the very greatly reduced malignancy of these tumors.

(4) **Cancer Cysts.**—These rare cysts are observed usually before the age of forty and are single. They resemble simple cysts in that they develop rapidly and may be situated anywhere in the breast. They differ from them in being single, in having a somewhat thicker wall, and in the rapidity with which they grow, but especially in the fact that they contain blood.

The cases observed at the Johns Hopkins Hospital and described by Halsted and Bloodgood have borne a very close relationship to lactation and mastitis, differing in this respect from simple cysts and cysts with intracystic papillomatous growths.

These cysts are the rarest variety of cancer of the breast, and in Halsted's clinic are found to be the most malignant.

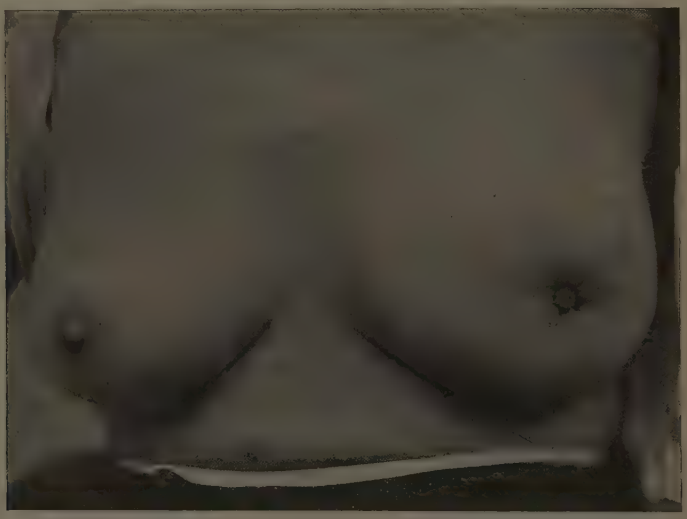

FIG. 338.—RETRACTION OF NIPPLE IN CARCINOMA OF THE BREAST. (Keen.)

(5) **Paget's Disease of the Nipple.**—A very rare affection. In 1874, Sir James Paget described a chronic lesion of the nipple and areola followed by carcinoma of the breast, which has since borne his name.

The disease occurs late in life, after the period of lactation. It is rare in virgins and in those who have not lactated. The patient first notices burning and itching in the region of the nipple. This is soon followed by an eczematous skin affection, beginning on the nipple itself and spreading concentrically over the areola and surrounding skin. The surface appearance varies considerably. In some instances it presents an intensely red, granular surface; in others it is covered with yellowish-brown crusts, and in still others islands of new epithelium are seen. In all cases the nipple contracts early, usually within one year. A sign of great importance is the parchment-like induration of the skin. This condition may persist for months or years, but is eventually followed by carcinoma of the mammary gland. The interval in most cases has been from one to three years. Jacobaeus states that even

when no tumor could be demonstrated macroscopically the microscopic study has invariably shown the presence of cancer.

Difference of opinion as to the nature of Paget's disease has necessarily caused confusion in the conceptions of its pathology. Taking as a definition what seems to have been the original idea, that it is a disease of the mammary areola preceding cancer of the mammary gland, it is possible to eliminate at once much unnecessary discussion. Cumston has defined it more accurately as a chronic pathologic process involving the skin of the nipple and areola, accompanied by a carcinoma in the mammary gland. According to Jacobaeus this carcinoma is either a superficial spongy mass growing at the site of the retracted nipple or it may develop in the depths of the gland like the usual tumors, or both may exist, connected by carcinomatous tissue. The disease is characterized microscopically by large bright cells (the so-called Paget's cells), lying singly or in groups in the deeper layers of the epidermis. From his studies Jacobaeus came to the definite conclusion that Paget's disease is from its onset a carcinoma springing from the glandular epithelium of the milk-ducts. Independently, Schambacher came to the same conclusion. Ribbert, upholding this view, says that the fundamental conception is the recognition of the fact that the primary process is the formation within the nipple of a carcinoma composed of brightly staining gland cells. Hand in hand with the carcinomatous infiltration there is produced an inflammation of the surrounding tissues, giving the likeness to eczema.

It must not be inferred from the preceding that eczema of the nipple does not occur, but only that such is not Paget's disease. The reason for going so extensively into this subject is to make clear its inherent malignant nature in contradistinction to the view that its association with carcinoma is only incidental.

Multiple Primary Cancers.—The simultaneous occurrence of cancer in both breasts ($\frac{3}{4}$ of 1 per cent. to 5 per cent.) is more common than the appearance of two or more distinct primary carcinomatous foci in the same breast. In these infrequent cases it is probable that the cancers are usually the result of malignant transformation of pre-existing benign conditions, such as tumors, or more particularly chronic cystic mastitis (senile parenchymatous hypertrophy), as in a case reported by Le Dentu and Morestin. Cases of primary carcinoma of the breast associated with primary carcinoma in other structures than the breast—*e. g.*, uterus or ovary—are also rare. Instances of cancer of one breast with the occurrence of benign or sarcomatous tumors in the other are less uncommon (Coley).

Secondary Cancers.—Such tumors must reach the breast by direct extension from cancers primary in adjoining structures, or by metastases from those more remote. The most frequent form is the metastasis from cancer in the other breast. Carcinomatous metastasis from other organs is very rare, sarcomatous less infrequent.

Clinical.—Like most diseases, cancer of the breast may be divided clinically into acute and chronic varieties.

The acute form (mastitis carcinomatosa, Volkmann) is fortunately rare, as it has proved rapidly fatal, the whole course lasting at times but two or three months, rarely a year. It appears during or soon after the puerperium, simulating or complicating the ordinary mastitis, though 1 case was engrafted upon a tumor of a year's duration (Rosenstein). So great has been the virulence of these tumors that by the time a diagnosis has been made operation was futile, as internal metastases had occurred and developed with equal rapidity. Both scirrhus and medullary types have been found.

In the ordinary chronic forms the onset is so insidious that the presence of the tumor is discovered only accidentally and probably after a lapse of months. Less frequently attention is attracted to the growth by spontaneous pain, dull or lancinating, or as a consequence of posttraumatic discomfort. In very unobserving individuals the appearance of a discharge from the nipple or ulceration of the skin leads to the discovery of the tumor.

The patients are usually in very good condition, the tumor is small, freely movable with the breast, is not painful or tender nor apparently increasing in size, a combination of circumstances fostering the belief that the trouble is inconsequential.

For an indefinite time there is no marked external evidence of progressive enlargement. In time (months), however, the permanent and progressing enlargement becomes unmistakable. This generally occurs spontaneously, but may be occasioned by intercurrent pregnancy or by traumatism. The rate of growth is also influenced by the malignancy of the tumor and its pathologic structure.

Location.—The breasts are affected in approximately the same proportion, although in the experience of individual clinics one or the other may show considerable preponderance. In Paget's disease the right breast is involved three times as frequently as the left. Both breasts are invaded in from ¾ of 1 per cent. to 5 per cent. of the cases. The cancer is more commonly located in the upper and outer than the lower or inner hemispheres, most frequently in the upper and outer quadrant and in the central retro-alveolar portions.

Axillary Glands.—These were palpable in 84 per cent. of the cases (2 per cent. were immovable) and their presence recognized in ten to thirteen months.

Adhesions.—The invasion of contiguous structures is determinable only by the formation of adhesions of the tumor to them, so that cases are divisible into the adherent and nonadherent, as regarding the skin, muscle, and chest wall, in the order of the frequency of involvement. Rosenstein estimated the adherent cases at 84 per cent.

Supraclavicular Glands.—Enlargement was noticed in 10 per cent. eight months after the axillary involvement, or eighteen to twenty-one months after the tumor.

Internal and Other Metastases.—These were usually recognized later—twenty-three to thirty-eight months—and were very widely disseminated, occurring most frequently in the skin, liver, lungs, pleura,

PLATE VII.

CARCINOMA OF THE BREAST.

stomach, other breast, spine, sternum, femur, humerus, skull, and central nervous system, in the order named.

Carcinoma en Cuirasse (Velpeau).—This peculiar manifestation of retrograde lymphatic dissemination of the carcinoma has become exceedingly rare. It consists of more or less confluent skin metastases involving a considerable area of the chest with remarkably little tendency to internal metastases.

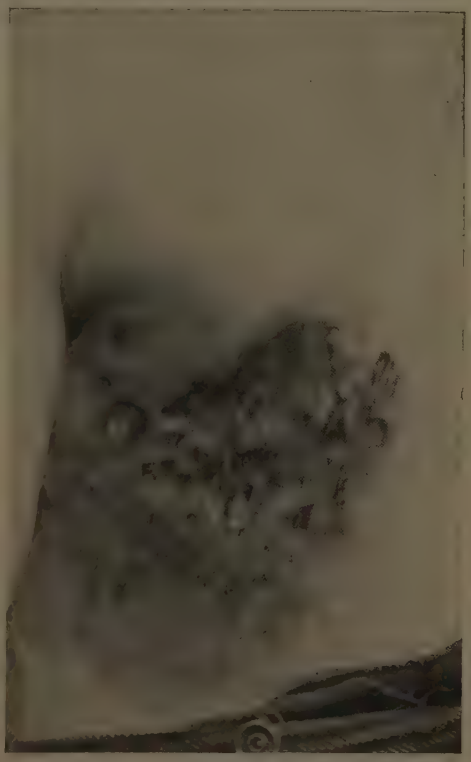

FIG. 339.—CANCER EN CUIRASSE. (Dudley P. Allen.)

Retraction of the Nipple.—This occurs in about 20 per cent. of cases, and a discharge from the nipple less frequently (7 per cent.).

"Pig skin" or *"orange skin"* is a far more frequent manifestation and more significant, though not pathognomonic.

Treatment.—The condition is hopeless. Palliative measures, such as the *x*-ray, etc., are to be practised chiefly for their mental effect.

Diagnosis of Carcinoma of the Breast.—Difficulty in making a diagnosis rarely arises except in the early cases, where immediate recognition is the most imperative. It is in just these cases that a positive diagnosis is frequently impossible, but the indication for surgical treatment is usually both unmistakable and absolute.

The recognition of typic or advanced cancers is so simple that only the early cases will be considered.

History.—There is but one essential fact in the anamnesis, the occurrence of a tumor, though its appearance after the thirty-fifth year is significant. In every case the important point is the recognition of malignancy, and nothing in the history will definitely settle the question if it cannot be determined by physical examination.

Inspection.—If no definite abnormality is recognized on inspection, the patient should then be instructed to change her position. Retraction of the skin may appear over the site of the tumor or a slight unnaturalness in the mobility of the breast be apparent. Such an observation in an individual with large firm breasts and a small deep-seated nodule

may be the one definite clue to the diagnosis obtained in the entire examination.

Palpation.—Both the flat of the hand and the tips of the fingers should be used in turn. The weight (when sitting), consistency, distinctness of lobulation, mobility, and sensitiveness should be determined and then compared with the unaffected side. When the tumor has been located, its size, shape, sharpness of outline, and consistence should be determined, then whether it is confined to the breast tissue, whether it is movable therein, and the nature of its attachments to the skin, including the nipple or underlying tissue. The superficial attachments are oftentimes easiest recognized by gently grasping the circumference of the base of the breast with both hands and gently lifting it forward, when an adhesion will often manifest itself by a retraction of the corresponding area.

Palpation of Lymph Glands.—In typic cases this is superfluous as a purely diagnostic measure. In the difficult and early cases it is of little value. Enlarged glands do not necessarily signify metastases even in the presence of cancer, and impalpability is no evidence that they are not already involved. Moreover, they may be present and only on the affected side in purely benign conditions. In the more advanced cases, where the diagnosis is certain, the recognition of glandular enlargement is of great importance as a guide to the proper operation to be performed and also to the prognosis.

Those cases which do not permit of a definite diagnosis externally, warrant an immediate direct examination of the lesion through an exploratory incision.

Treatment of Carcinoma of the Breast.—Under this heading are included prophylactic, diagnostic, curative, supplementary, and palliative measures.

Prophylactic Treatment.—In the consideration of the etiology certain factors seem to have more than a casual significance, and among these, mastitis—(1) infective and (2) involutional—and (3) benign tumors are to some extent subject to medical control.

(1) As already stated, infective mastitis is said to occur in 6 per cent. of cases in the puerperium. According to Williams the occurrence of over 1 per cent. in a series of cases is indicative of carelessness in obstetric treatment and is, therefore, preventable. When the inflammation has entirely subsided, if a troublesome mass persists, there would be ample justification for its excision.

(2) Involution changes constantly occur at the time of the menopause. When this condition has advanced sufficiently to have been recognized, it has progressed far enough to bear careful watching.

These breasts are of little or no functional value, and at this age not even the cosmetic plea can with justice be raised as a contra-indication to their removal after signs of activity have begun to develop. The operation, to be effective, must be complete. The excised breasts should be examined at once for evidences of malignancy, the discovery of which demands immediate and still more radical intervention.

(3) No tumor can be adjudged so benign that it will never become malignant, and no tumor will ever be more benign than when first recognized. There is only one sure cure for any benign tumor, solid or cystic, and that is its complete removal.

By making use of Warren's elaboration of the Thomas incision, little disfigurement or functional derangement need result from the operation. Large tumors, however, may indicate complete removal of the gland.

Diagnostic Treatment.—The procedures now in use are as follows:

(1) The *abstraction of tissue* from a suspected nodule for microscopic examination by the use of some instrument, such as a punch or harpoon. Richardson has pointed out from actual observation the worthlessness and the risks of this method.

(2) *Two-stage operations*, excising tissue at the first sitting for microscopic examination, with closure of the exploratory incision and subsequent complete operation at another time. This method will more certainly secure the desired tissue, but if malignant it will just that much more certainly spread the disease to healthy structures.

(3) *Exploration of the questionable mass* with or without the excision of a piece of suspected tissue, which may be subjected to immediate microscopic examination. The operation thus determined is performed at once. This method has the disadvantages of requiring the presence of a skilled technical pathologist with expensive pathologic paraphernalia.

(4) *Immediate complete excision of the breast* or of that portion of the breast containing the suspected nodule. A section is made through the entire tissue removed, passing directly through the center of the tumor. Naked eye inspection will, in the great majority of cases, settle the diagnosis. If not, then serial sections can be cut and studied individually. One apparently serious objection to this is that it requires considerable pathologic training on the part of the operator. Under modern conditions, no man should consider himself competent to attack malignant disease who is unable to recognize malignant tissue when he sees it in the fresh condition. Another objection is that a person suffering from a benign lesion might be subjected to a radical operation for cancer because of a faulty diagnosis. Is it not better to subject a woman now and then to an unnecessarily radical operation with practically no mortality than to fail in a single instance to eradicate a disease having a mortality of 100 per cent.?

(5) A small incision carried carefully down to, but not into, a suspected nodule will often reveal its identity at once by its appearance and the character of its attachment to the surrounding structures.

A combination of these methods would be more ideal, but even then doubtful cases would occur, and it must never be forgotten that the presence of a scar, the loss of a breast, or the slight limitation in the use of an arm are inconsequential compared to a sacrificed life.

Curative Treatment.—Here should be combined all the knowledge gained from scientific work and clinical experience. Correct theory and

practise should coincide, so that each is a check upon the other. When there is disagreement, one or both will be found to be faulty. From the standpoint of pathology, a surgical cure of a cancer would depend upon a complete excision of the disease, a manifest impossibility when it has extended much beyond its point of origin. From the standpoint of surgery it is utterly impossible to excise merely the malignant tissue and at the same time to accomplish a cure. The incisions must be made entirely outside of diseased structures. In other words, they must be made only through healthy tissues. From a practical standpoint the only justifiable routine operation is one that will completely remove the entire malignant disease in every case where it is possible, which means the removal in one mass of all the tissues that might be involved. From a clinical standpoint experience has shown that when certain structures are involved no justifiable operation, however radical, can probably be more than palliative in its ultimate effects, as such involvement has been found to indicate that ineradicable metastases are already established.

The *determination of these limits of involvement* in the different structures, when taken in conjunction with anatomic and pathologic facts, will then give the basis for an operation.

Skin.—Anatomically, the breast is in close relation to its entire integumental covering; pathologically any of this area of skin may be involved early; clinically, if a wider extent of skin is not excised, the disease is prone to reappear in this area. No definite rule can be given as to the exact amount to be removed. Rotter advises three fingers'-breadths outside of the limits of the breast in the neighborhood of the tumor. When the skin is adherent or when the tumor is at the margin of the breast even more should be removed. The only danger is from excising *too little.*

Adhesion of the tumor to the skin makes the prognosis less favorable, but not necessarily hopeless, even after ulceration has occurred. The appearance of discrete lenticular skin metastases is usually an indication that there are inaccessible metastases. No case with such skin metastases has been saved in the Johns Hopkins Hospital series.

The plan of the incision is of little consequence if the dangerous skin is disposed of. It should be so arranged as to give ready access to the entire field of operation and permit a closure that will minimize the restriction of the motion of the arm by allowing a satisfactory reconstruction of the axilla.

Fat.—This is even more dangerous than the skin, from being in closer relationship to the breast. The entire fatty envelope, together with that contained in the axilla, should be thoroughly removed.

Breast.—Moore, in 1867, recommended that the entire breast should always be removed. Now it is recognized that this removal should be so complete that no trace of mammary tissue is seen during the operation, for the reason that "By the time a cancer is demonstrable in a breast, metastases already exist. The gland is liable to be involved

throughout, and processes of malignant tissue to have extended from any part of its periphery."

Fascia.—The covering of the pectoralis muscle is involved earlier and more certainly than the skin, and contains malignant deposits long before any apparent adhesions are formed between it and the tumor. Its complete routine removal was begun by Volkmann in 1882. Rotter has advocated the excision of the fascia of the serratus magnus and external oblique muscles as far as they underlie the breast, but there has been no reason other than analogy advanced in favor of this step. Any invasion of the pectoral fascia, if only microscopic in extent, indicates that the muscle already contains cancer, but otherwise is not in itself of any practical significance. This fact can be accepted as a positive indication that it is never justifiable to attempt to dissect the fascia from the muscles.

Muscle.—The most generally accepted modern radical operation includes the removal of the pectoralis major. This was first advised in 1867 by Banks for those cases in which it was evidently invaded, and first advocated and practised as a routine measure by Halsted in 1888. The results of Heidenhain's investigations, published in 1889, and the improved results obtained in a series of cases recorded by Halsted in 1894, were responsible to a large extent for its more universal adoption.

Heidenhain found by examining 18 cases operated on by Küster that in spite of the most careful dissection, part of the fascia and tissue infiltrated with carcinoma was not removed in 12 cases. In 11 of these 12 cases the disease later reappeared locally, the twelfth was not recorded. The other 6 escaped. He became convinced that all cancers eventually send their outposts to the muscle, and therefore advised the removal of the anterior surface of the muscle with the fascia in non-adherent cases and of the entire muscle when the tumor was adherent to it. Since then it has been repeatedly observed and recorded (Halsted, Rotter, and others) that isolated carcinoma nodules may occur in the muscle even when there are no adhesions, and this is by no means limited to late or advanced cases. Moreover, the retropectoral glands and fat are frequently involved even in early cases, and it is a surgical impossibility to remove them if the pectoral muscle is not excised. For similar reasons the pectoralis minor muscle cannot be retained with safety, and its removal facilitates the axillary dissection and the healing of the wound. Adhesions of the tumor to the muscle make the outlook unfavorable, but not necessarily hopeless.

Excision of the muscles can be effected in two ways, according to the preference of the operator, without materially affecting the ultimate result. Halsted, Meyer, Warren, and others have suggested methods which bear their respective names, but they differ little in the essentials. Either beginning at the insertions by severing the attachments of the pectoralis major to the humerus and of the minor to the coracoid process, thus giving an early exposure of the axilla, which can then be dissected from above downward, or *vice versa*, and later cutting the attachments; or starting with attachments which are severed from

below upward, thus making the greater part of the dissection toward rather than away from the axilla. By employing the former method the operation can be done more rapidly, with less hemorrhage, but, more important still, the main lymphatic connections are all severed before the breast is disturbed, thus perhaps lessening the danger of causing metastases by the manipulative traumatism to the main tumor.

Lymph Glands.—Axillary.—Volkmann began excising the axillary glands where they were palpable at operation. Küster, in 1883, first advised the thorough removal of the axillary contents as a routine proceeding. In several series of operative cases these glands have been reported as carcinomatous in 83 to 100 per cent. Positive evidence of metastases has been obtained in cases operated upon as soon as the tumor was noticed, justifying the assumption that every bit of axillary tissue is always directly or indirectly dangerous.

When all of the lymph glands are involved or when they are adherent to the vein the prognosis is hopeless for ultimate recovery, but not for immediate relief, which may last for several years. As a rule, when the uppermost glands in the axilla are carcinomatous, a cure is improbable, even if the involvement is not otherwise extensive.

The dissection of the axilla may be accomplished from apex to base or from base to apex and by the use of instruments, or gauze, or both. If done hurriedly or roughly, any method is dangerous and uncertain. This is the one difficult and tedious part of the operation, and must be done so carefully and thoroughly that every bit of tissue shall be removed with the first attempt, in order to avoid the possibility of tearing through infected lymphatics. Gauze dissection is more rapid and when completed looks cleaner than the instrumental, but it involves more traumatism to the tissues. Whether this has practical significance or not there is no way of judging at present. None of the vessels or nerves traversing the axillary space are essential, and attempts at their preservation are never without danger of leaving infected tissues.

Extra-axillary.—These glands have never been sufficiently emphasized as dangerous. They lie just beneath the sternal attachments of the great pectoral muscle and between it and the minor. Rotter found them involved in 11 out of 33 cases and thought that they are invaded as early as the axillary glands, if less regularly.

Cervical Glands.—These are palpable in 10 per cent. of the cases, and of these cases the enlargement is due to cancer in at least 50 per cent. For a time the dissection of the supraclavicular fossa was advised and practised in every case, but subsequently it was discontinued as a routine practise, so that this part of the operation is now used only in cases where the uppermost axillary glands are found to be carcinomatous or where the supraclavicular glands are palpable.

Closure.—This may be effected by some form of plastic surgery or by immediate or subsequent skin-grafting. An operation that can be completed safely and satisfactorily in one stage is always desirable. But any incision designed only to permit of a good closure rather than

the removal of a sufficiently wide area of skin is never to be contemplated.

Drainage is, as a rule, safer and, therefore, to be advised. The drain may be inserted through a counteropening low in the axilla at the level of the angle of the scapula.

Supplementary Treatment.—Anything that promises to make more certain the curative measures employed is well worth consideration. Everything that tends to improve the general health should be made use of, and encouragement constantly given to the patient to resume activity as soon as possible. No drug is indicated except as tonics may be necessary. Arsenic has been recommended by some, but it is not a specific.

The *x*-ray has no efficient curative effect upon the primary tumor, but apparently it has occasionally caused the disappearance of early recurrences. Radium is of doubtful value.

Palliative Treatment.—This is local, directed against the disease itself, or general when an attempt is made to control its progress by measures affecting more or less the entire organism. Local treatment may be classified as primary or secondary, as directed against the original disease or its postoperative reappearance.

Primary.—Any form of treatment that does not promise an opportunity for a cure must be classed as palliative, even though it may result in years of apparent recovery. This will include that class of cases where there was at the time of operation no evidence that all malignant tissue had not been removed, but where, for instance, the existence of cutaneous metastases or carcinomatous supraclavicular glands indicated the probability that the disease was already more widely disseminated.

A second class of cases, still more advanced, would be found before or during operation to be hopeless, in that all of the cancer could not be excised. The question of the propriety of operating on such individuals is frequently raised. The answer is emphatic. A radical operation done under these conditions offers the possibility of mental relief based on the hope of life given by the permanent disappearance of the local disease. Life will often be lengthened materially, though exceptionally it may be considerably shortened, but, more important still, the suffering of the next group may be avoided.

In a third class may be placed the unfortunates who need relief from physical as well as mental distress, intractable stinking ulceration, neuralgia from involvement of nerve trunks, painful swelling of the arm from extensive axillary involvement, and various combinations of these conditions. Here again the most radical operation is the most humane, offering the only chance for permanent local relief and at times even securing a considerable interval of perfectly comfortable existence. Where the axillary or brachial plexus involvement is the principal offending cause, interscapulothoracic amputation as advocated by Lane offers the greatest chance for a local relief that will be as lasting as life, which, indeed, it may materially prolong.

In a last class fall the most distressing cases, those dying from the effects of deep and painful metastases, visceral, bony, or in the central nervous system. Morphin and even chloroform become useless at times, and under such conditions anything short of euthanasia that will reduce discomfort is justifiable. The most intolerable of all suffering, paraplegia dolorosa, might be relieved, as Cushing suggests, by dividing the cord above the lesion.

Secondary.—At present it is generally accepted that so-called recurrences are but the subsequent development of carcinomatous elements not removed by the operation, even though they may have remained latent for years. Recurrences may be termed local, appearing in the field of operation, that is, in the apparent or buried scars, or regionary, *i. e.*, the occurrence of lenticular metastases in the neighboring skin. Both indicate that the operation had been insufficiently radical or that during the operation viable cancer cells had been implanted upon the exposed tissues.

If the character of the recurrence is such that its excision is possible and there are no contra-indicative internal metastases, this should be done as promptly and radically as conditions warrant. Though a cure is not to be expected, many additional years of immunity may be thus secured. Whether it is ever justifiable to open the anterior mediastinum or to remove ribs and parietal pleura cannot be settled arbitrarily. Usually such efforts are of no avail, though at times life has apparently been prolonged thereby (Elliot). The *x*-ray may help in controlling pain and retarding the growth.

General.—Since it has been observed that double oöphorectomy would cause a precipitation of the menopause with a consequent involution of the mammary tissue, this procedure has been advocated in the treatment of ineradicable cancers of the breast in the hope of exerting thereby some inhibitory influence upon their growth. This treatment, rediscovered by Beatson (*Lancet*, 1896, 11, 104), has enjoyed some popularity. Many cases have been reported as benefited and a few alleged cures recorded. It seems to be efficacious only in cases less than fifty years of age and then even if the menopause had already occurred. Lett collected 99 cases and found that 36 per cent. were benefited, 23 per cent. markedly improved, and if patients over fifty were omitted, 41 per cent. were improved. Roubaud records 51 cases, in 23 there was improvement, but this was lasting in only 3, and in the other 28 cases there was no result. This evidence would apparently justify the operation in suitable cases, but too much should not be expected from it.

Prognosis.—This problem is inseparable from the results of operative treatment, and such results are based on statistics that are virtually worthless, because the nature of the treatment is so variable, not alone in the hands of different operators, but the same man's methods change and improve with experience. There is no criterion of an absolute cure except the post-mortem demonstration that a body is free from cancer. The only possible just test of the value of an operation is its

capability to effect a local cure. Volkmann's three-year limit does not hold even for local recurrences, but it is the generally accepted standard, and is, therefore, the only available index.

Mortality.—Cases not operated on prove fatal on the average in twenty to twenty-eight months, the extremes varying from less than two months to more than twenty years. Cases operated on but uncured, in which the disease reappears in less than three years, live thirty to thirty-eight months on the average, a gain of ten months over similar cases not operated on. The average length of life after operation has been estimated as from fourteen to twenty-five months under these conditions. The mortality from the operation itself has been reduced from 23 per cent. in the first series of Billroth's cases until now it is 1 to 2 per cent. or less in reliable clinics, although apt to be larger if the results of palliative treatment are included.

General Cures.—These supposed cures depend upon complete freedom from all evidences of the disease for at least three years after operation. From being a virtually incurable malady, the percentage of these recoveries has advanced with the gradual improvement in surgical therapeutics until this degree of relief may be expected in about 40 per cent. of all cases. Cheyne reported 57 per cent. The fallacy of this arbitrary time limit as an index of cure is well shown by the late results of a series of cases studied by Smith. At the end of three years there were 43 per cent. of cures, but without this limitation the percentage fell to 17. Barker estimated that 30 per cent. of those living three years after operation died later of cancer.

Local Cures.—Measured by the same three-year standard, the percentage of local relief is, as might be expected, in excess of that of complete relief. Halsted found 52 per cent. of local and regionary freedom from the disease, and 41 per cent. of apparent cures.

Frequency and Rate of Local Recurrence.—Following incomplete operations, usually where the muscles are not excised, these recurrences appear in 45 to 55 per cent. of the more modern and 85 per cent. of the older operations, as opposed to 6 to 19 per cent. when the complete operation has been done. In Volkmann's individual experience there were fewer (58 per cent.) local and regionary recurrences in his worst cases where the muscle was excised, though not radically enough even then, compared to the more favorable cases (60 per cent) where no excision was attempted; 20 per cent. of those who died in the first three years have been shown to have had local recurrences.

Recurrences may appear at any time from within a few days of the operation up to thirty years thereafter. The majority occur early, 40 to 60 per cent. developing in the first six months, and over 50 per cent. of these in the first three months. From this time the rate of recurrence rapidly and progressively diminishes. It has been estimated that but 2 per cent. appear after the third year, but this is probably too low. Regional recurrences rarely occur after the first year.

General Metastases.—These are said to occur in 17 per cent. of all

cases. They occur early and unaccompanied by any local recurrence in 30 per cent. of these cases.

Details of Prognosis.—In general the prognosis follows the law published by Andrews: "The risk of recurrence in malignant disease increases as the square of the time of growth, or, conversely, the risk of recurrence diminishes in the ratio of the square root of the time after incidence."

More particularly, as has already been stated, the prognosis depends upon (1) the duration and (2) malignancy of the tumor, (3) the extent of the existing involvement, and (4) the period of life at which it appears.

(1) Pathology and clinical experience teach that the sooner proper treatment is instituted, the better the chance for a cure. Warren's accurate statistics are a striking practical demonstration of this fact. By dividing his cases into three groups, according to the period they were operated upon, he found that of those treated before visible growth began, 42 per cent. were cured. Of those operated upon after visible growth began, but before the tumor became adherent, 17 per cent. were cured, and of the later cases, after adhesions were present, but 5 per cent. were cured.

(2) The percentage of cures is in inverse ratio to the malignancy, as judged from the viewpoint of pathology, and the best average results have been obtained in the following order: colloid, adenocarcinoma, Paget's disease, scirrhus, and medullary carcinoma, although the experience of individual clinics differ somewhat from this.

(3) When adherent to the skin the prognosis is unfavorable. Warren's cures under this condition were but 17 per cent. No figures are available as to the effect of adhesions to the muscle, though in some series none of these cases were cured. When the axillary glands are not involved the prognosis is very much better, Warren obtained 64 per cent. of cures under these conditions. In Halsted's clinic 7 per cent. of the cases well for three years had had metastatic glands in the neck (Bloodgood). No case having lenticular skin metastases nor one in which the tumor had become adherent to the chest wall is recorded as cured.

(4) The greater the age of the patient at the time of the appearance of a tumor the relatively less malignant it appears to be (Billroth), though contrary opinions are held (Dennis).

Prognosis after Second Operation.—Thus far the prognosis at the first operation has alone been considered. The real opportunity to effect a permanent cure is at that time, but the outlook for a considerable prolongation of life at the second or even the third operation is not necessarily hopeless, though the possibility of a cure is very remote. The majority of cases showing recurrences are little benefited by re-operation, but many are so much improved that it is usually indicated, especially when the recurrence appears after a considerable interval. One case having had four operations, including amputation of the second breast and a recurrence on that side, was apparently well twelve

years later (Hutchinson). One case, recurrence after nine months, second recurrence twenty-two years after the second operation (Wolbarst).

Prognosis after Palliative Operation.—Little that is definite has been published in respect to the late results of palliative operations, though in the experience of every clinic, cases which were expected to die in a limited time remained apparently well for years. Warren treated 13 hopeless cases by radical operation, and of these 1 lived two years, 3 lived three years, and 1 lived eight years.

Conclusion.—The most successful treatment of cancer of the breast depends upon an optimistic radicalism, not so practical as to be unscientific and yet not so scientific as to be unpractical. A radicalism which, in the realization of the absolute fatality of the disease if improperly treated, will find the courage, the energy, and the patience to secure for each individual to the fullest extent every opportunity there may be for a prolonged and more comfortable existence, even if a complete recovery is impossible.

The **steps in the operation** for cancer of the breast as I usually perform it are essentially those originally described by Halsted, and are as follows:

The most important point to be considered in the choice of incision is that it should include enough skin. Any one of several classical incisions will be found satisfactory. It should be made to conform to the location of the growth. The amount to be removed having been outlined, as shown in Fig. 340, the next important step is the dissection of the skin flaps, beginning preferably with the upper outer one, as shown in Fig. 341. The skin flaps should be reflected all around the area of skin to be removed, leaving exposed the fat covering the breast and the axillary structures, as far back as the free border of the latissimus dorsi, the posterior boundary of the axilla. Care should be taken to remove every vestige of breast tissue; in other words, one should not see breast tissue until after it has been removed.

The next step in the operation is the division of the pectoralis major close to its insertion into the humerus. It should be divided on the finger, from without inward (Fig. 342). The divided muscle is then retracted downward and inward, and the upper part of the pectoralis minor covered with its overlying fascia then comes into view. This also is divided on the finger. The axillary vessels and nerve trunks are now exposed by dividing the overlying fascia. The incision of the fascia is carried along the vessels up to the clavicle, where there comes into view the uppermost fibers of the clavicular portion of the pectoralis major. These are freed and divided. The fingers of the left hand are now inserted from above downward between the remaining fibers of the pectoralis major and the chest wall (Fig. 343). The muscular fibers are thus lifted from the chest and made tense, rendering their division on the fingers easy. Just enough margin of the muscle should be left to secure the bleeding vessels, which can easily be seen and clamped before they are cut.

FIG. 340.—SKIN INCISION.

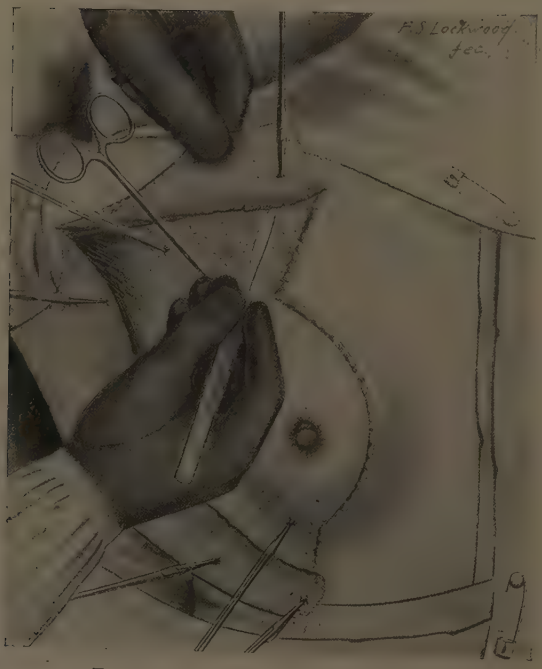

FIG. 341.—REFLECTION OF SKIN FLAPS.

FIG. 342.—DIVISION OF PECTORALIS MAJOR AFTER THE TISSUES TO BE REMOVED HAVE ALL BEEN EXPOSED.

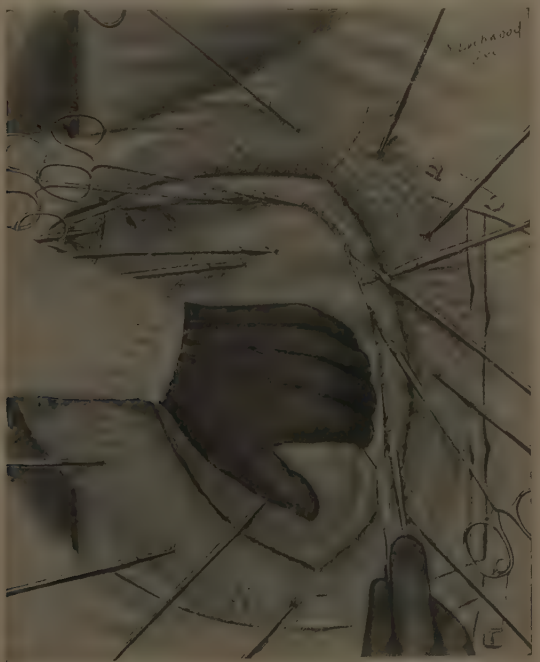

FIG. 343.—DIVISION OF ATTACHMENT TO CHEST WALL.
The excised mass gravitated outward and downward.

FIG. 344.—STRIPPING THE AXILLARY VESSELS AFTER DIVISION OF THE FASCIA.

FIG. 345.—DIVISION OF THE PEDICLE OF THE EXCISED TUMOR MASS.
The final step in the operation.

The breast and divided pectoralis major now drop downward, exposing the origin of the minor, which is divided in a similar manner. Beginning now at the lower border of the clavicle, the vessels and nerve trunks are cleaned absolutely free of all fat, lymphatic and other tissues, from above downward. The vessels and nerves are thus fully exposed in the apex of the axilla (Fig. 344). The dissection is carried down along the vessels as far as the outer border of the axilla, the various branches, both venous and arterial, being exposed and divided between two clamps. The axillary fat, lymphatic vessels, and glands, involved and uninvolved, the vascular attachments having been divided, can now be readily separated from the axillary artery and vein and from the scapular muscles and chest wall, being held by loose areolar tissue only.

Fig. 346.—Thiersch Skin-grafts Applied to Denuded Surface after the Insertion of Purse-string Sutures.

The breast together with its overlying skin and fat, the pectoral muscles and fascia, the axillary glands, lymphatics, and smaller vessels and nerves with their surrounding fat, after dividing the subcutaneous tissue along the free border of the latissimus dorsi, are now removed in one piece.

Aside from the brachial plexus, the only nerves which need be saved are the subscapulars. They should be sacrificed rather than run the slightest risk of leaving infected tissue. If the proper amount of skin has been removed it will generally be found impossible completely to close the wound. After replacing the skin flaps as advantageously as possible the remaining portion of the wound should be immediately covered with skin-grafts after the method of Thiersch (Fig. 346). If

in the reconstruction of the axilla sufficient care is exercised in keeping the axillary skin flap tucked well up into the apex of the axilla by means of properly applied pads of gauze, the subsequent usefulness of the arm will be found little impaired.

THE MALE BREAST.

The differences, both anatomic and pathologic, between the male and female breast are in degree rather than in kind, since in all essential particulars the development and morphologic structure is identical, except that in the male it remains rudimentary. It follows, therefore, that the same diseases and neoplasms except those having to do with the function of the gland are met with in both sexes.

As would naturally be supposed, the male breast is found to be affected much less frequently than the female. There are no diseases peculiar to the male breast. Up to the time of puberty the development of the breast in the two sexes is identical. At this time that in the male ceases and remains stationary until about middle life, when retrogressive changes begin.

The disturbances occasionally noted as occurring in the male breast at birth and puberty have been already discussed in connection with similar changes in the female breast.

Gynecomastia.—Ancient literature mentions numerous instances of well-marked functional development in the male. At the present time, however, it must be of very infrequent occurrence, as cases are recorded only at rare intervals.

The enlargement may be composed almost entirely of fat or it may show an increase in the fibrous stroma and parenchyma. It may be unilateral. Two types have been described: in the one the condition is associated with normal sexual function and development, while in the other testicular defects, either of congenital origin or the result of injury or disease, are always present.

The condition is of no consequence and demands no treatment except excision for relief of the deformity, in which event plastic resection is to be recommended.

Mastitis is a relatively rare affection of the male breast, owing to the absence of lactation phenomena. Acute mastitis and abscess are usually the result of traumatism, but may be associated with other conditions, *e. g.*, necrosis of the rib, tuberculosis, syphilis, infected cysts, etc.

Chronic Mastitis.—Certain forms of chronic mastitis have been observed associated with marked induration, and have been mistaken for carcinoma. They may be of gouty or syphilitic origin and associated with disease of neighboring structures. In this category comes the interesting hypertrophy of the breast in the male described by Leudet, in association with pulmonary tuberculosis on the corresponding side. This hypertrophy, however, is not of tuberculous but inflammatory origin, and may be transitory. No treatment is advisable.

Tumors.—Tumors of the male breast occur with much less frequency than in the female. The relative proportions have been variously estimated, but, roughly speaking, about 1 per cent. of all tumors occurring in the breast are to be found in the male. Schuchardt gives percentages from $1\frac{6}{10}$ to $8\frac{4}{10}$, obtained from various clinics.

Cancer occurs with slightly greater frequency than all other tumors combined. Of the benign tumors, *adenofibromata* and *cysts* apparently occur with greatest frequency.

Instances of *lipomata*, *enchondromata*, *papillomata*, and *angiomata* are recorded in the literature, but they are not numerous. They

FIG. 347.—HYPERTROPHY OF THE MALE BREAST. (Prof. Robert D. Murray, I. M. S.)

FIG. 348.—HYPERTROPHY OF BREAST IN A BOY AGED FIFTEEN YEARS. (Coplin.)

present the same characteristics as similar growths in the female, and should be treated accordingly.

Fibro-adenoma is one of the relatively common affections of the male breast. The cases that have been reported differ in no respect from those that have been described as occurring in the female.

Cysts.—The literature is relatively rich in number and variety of cysts occurring in the male breast. Instances have been noted of senile parenchymatous hypertrophy accompanied by cyst formation, presenting all the characteristics of this interesting affection which have been previously noted. Sebaceous cysts, hydatid cysts, dermoid cysts, cysts with intracystic papillomatous growths, and cystic degenerations occurring in the course of other benign and malignant tumors have been recorded.

Authentic instances even of galactocele have been reported by Velpeau and others.

Sarcoma.—The very few instances of sarcomata which have been

observed have usually been of the spindle-celled variety. They not infrequently take their origin in moles on the skin over the breast. Sarcomata of secondary origin have not been observed in this locality.

Carcinoma.—As in the case of the female, the all-important question to determine in the case of a given tumor in the male breast is whether or not it is malignant. The subject has been carefully studied by Poirier, Schuchardt, and Warfield. They have collected from the literature and studied a total of 509 cases of carcinoma of the male breast.

The age of onset seems to be a little later than in women—about sixty years. Both breasts seem to be affected with the same degree of frequency. Here, as in the female, trauma seems to play no very important rôle, although occupation seems to have some effect, *e. g.*, shoemakers.

Pain was not a prominent symptom in the majority of cases.

Ulceration was present in less than 50 per cent.

Retraction of the nipple was noted in about one-third of the cases. The axillary glands were enlarged in about 70 per cent. of the cases.

Pathology.—Macroscopically the usual characteristics of carcinoma were observed. Microscopically, no peculiarities of structure in the male cancers were made out, the majority were found to be of the scirrhous type, but instances of every variety have been observed.

The prognosis and mortality are the same as in women.

Treatment.—Here, as in the female breast, the only justifiable procedure, except in clearly hopeless cases, is complete radical excision.

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CHAPTER XLIII.

SURGERY OF THE MOUTH, TEETH, AND JAWS.

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THE MOUTH.

Development.—The buccal cavity first appears as a depression in the epiblast (the stomodæum) between the frontonasal, the maxillary, and the mandibular processes. The mouth is at this time separated from the pharynx, but the partition soon wears away. The facial part of the head is developed from bar-like growths from the cranial base, some in front of and some behind the buccal cavity.

The *pre-oral* plates are the frontonasal, the lateral nasal, and the maxillary plates. The *post-oral* are the mandibular and the hyoid pairs, and three others which are lower down the neck.

The *branchial clefts* are the slits between the plates where the cervical epiblast blends with the pharyngeal hypoblast. From the first cleft the Eustachian tube and the tympanum are developed. The *mouth* lies at the median portion of the mandibular fissures, which run between the maxillary and the mandibular plates. If the hinder ends of these fissures fail to become duly obliterated a large mouth, **macrostoma,** is the result. A less imperfect closure of the mandibular fissure may give rise to a cyst in the cheek. These conditions may be remedied by the judicious use of scalpel and sutures.

A very rare deformity is that in which too much of the mandibular fissures has been closed, the mouth being left small, **microstoma.** It may be treated by incising the cheek at the angles of the mouth and stitching the mucous edge to the skin. Imperfect closure of the post-oral clefts may leave a mucous pouch which, later on, filling with fluid, may bulge into the floor of the mouth, where it is apt to be mistaken for a simple ranula.

The existence of congenital sinuses or cysts, or of cysts developing in the lips, cheek, or mouth in early life, may generally be explained on the theory of imperfect fusion of the various embryonic plates with each other in the neighborhood of the mouth. And in the same way the presence of certain wart-like processes or pendulous tags may be accounted for. The best account of them is given by Lannelongue.[1]

The duct of the parotid gland (Stenson's) enters the mouth by piercing the buccinator opposite the second upper molar tooth. The duct of the submaxillary gland (Wharton's) opens on a conspicuous

papilla at the side of the frenum linguæ, near which are the (Ravinian) openings of the sublingual gland.

The mouth is continuous behind the soft palate with the pharyngeal cavity, and thus, indirectly, with the posterior nares, the esophagus and the larynx.

The mouth is carpeted by squamous epithelium, so that carcinomatous growths of this area are of the squamous epithelial type. In the depths of the mucous membrane are racemose glands which may become dilated into small cysts.

In the operation for cleft-palate (p. 623), as in other procedures which are associated with the risk of free bleeding into the mouth, it is advisable to have the shoulders raised and the head well thrown back, so that the blood may escape by the nares instead of by the way of the larynx and esophagus. This "head-downward" position is of equal advantage to patient, surgeon, and anesthetist, and when the surgeon and anesthetist have become accustomed to it in sanguinary mouth-operations it is generally preferred. Keen[2] writes that he has repeatedly used the Trendelenburg position in the removal of pharyngeal and nasopharyngeal tumors, in extirpation of the tongue and jaws, as well as in operations upon the nose, tonsil, and palate, and in laryngectomy. He recommends its more general adoption. The patient is placed at about an angle of 35 to 45 degrees, and arrangements must be made by means of shoulder braces to prevent his slipping off the table.

Oral Asepsis.—Inasmuch as the mouth is teeming with bacteria, it is impossible to render any operation therein absolutely aseptic. The surgeon must, however, do his best to make the cavity as clean as it can be got before undertaking such an operation as that for cleft palate or for the removal of a cancerous tongue (p. 693). This he does by having the teeth well brushed with antiseptic lotions and, when necessary, scaled. Carious teeth are cleaned and filled or, if hopelessly decayed, extracted. Suppurating follicles about the throat or tonsils are efficiently dealt with, and spongy gums are washed with an astringent lotion. For two or three days before operation the mouth and also each nostril should be well sprayed with equal parts of listerine and a saturated solution of boric acid or some equally mild antiseptic. Such precautions having been taken, incised wounds often heal by first intention; and in cases when no such measures have been adopted it is a matter of daily observation that wounds of the mouth have a great capacity for taking care of themselves. Thus, a person stumbles with a pencil in his mouth and the sharp end is thrust through the soft palate; or, in a fall, the tongue is deeply bitten, and although these wounds are more or less contused, the timely introduction of a suture or two may, nevertheless, be followed by prompt healing.

Examination of the mouth should not be made in a perfunctory manner. The patient should for choice be placed opposite a good natural light or, failing this, the surgeon should be provided with an electric or some other artificial light with a reflector. If there is an overhanging moustache it should be got out of the way. A broad, flat

tongue depressor and a dental mirror should be at hand, and, these preparations being made (and the hands being washed in the presence of the patient), a thorough exploration of every part can be made. In the case of a child or other unruly person a gag may be needed. And if the part is covered with mucus or saliva it will be advisable to wipe it dry with a soft napkin before it is inspected.

Hare-lip.[1]—If a hare-lip is associated with cleft palate the palatine cleft has to be closed before the lip is dealt with. But, assuming that the infant is in a fair state of nutrition, and that the hare-lip is not associated with a defective palate, the sooner it is operated on the better. This may be undertaken at any time after the tenth day, and before that if need be. The operation should not be done without an anesthetic. Chloroform may be given on a piece of lint or on the stiff corner of a towel.

The freeing of the lip and cheek is one of the most important points in the operation, for unless this is thoroughly done the vivified edges cannot be got together across a wide gap without tension. The bleeding which occurs at this time can be stopped by clip-forceps and the surgeon must take care that the blood does not trickle into the mouth. As soon as the coronary arteries spurt they may be caught by the clips, and if the handles of the clips are then turned up toward the forehead, for the anesthetist to hold, the lip becomes everted and all bleeding points are brought out.

When the labial flaps have been loosened up the incisions are planned for obtaining the raw edges.[3] By the old method the mucous membrane was dissected from each side of the gap. This was wasteful of tissue, and when the surfaces were drawn together a triangular notch was apt to be left on to the free border of the lip. The borders of the lip should not be vivified by scissors; it cannot be done precisely enough in that way, and the scissors injure the tissues. A tenotomy-knife does not serve for the purpose, as, being made for strength, its back is thick; an old scalpel which has been worn thin by grinding serves excellently.

The red border of the lip being seized by fine dissecting-forceps, the mucous membrane is economically yet sufficiently peeled from one side of the cleft and from along a good deal of the free border of the smaller side of the lip, while from the other side a very bold flap is cut, as is shown in Fig. 349. This flap is afterward brought across to the denuded border of the lip upon the other side. Its thickest part, near *c*, forms the prolabium, while that part which was previously the mucous border of the vertical cleft, *ac*, becomes the horizontal border at the bottom of the obliterated fissure as well as of the opposite side of the lip. The piece to be brought across is not a mere paring, but a thick, wedge-shaped flap, which is boldly tilted down, so as to leave an angular space into which the opposite side of the lip, already denuded in its vertical and horizontal borders, may be dovetailed.

[1] For the embryologic explanation of the occurrence of Hare-lip, see the next section on Cleft Palate.

In this operation the scar, being deflected outward, may escape attention, as it gradually tails off to the free border

When the right half of the lip has been brought to the middle line the incision *ac*, which had been made obliquely into the lip (Fig. 350), becomes vertical, the thick flap, which had previously been vertical, becoming horizontal and ready to form the mucous border of the restored lip.

The right side of the lip being drawn inward, some of its freshened border, *ab*, is placed vertically, while the rest of it forms a horizontal edge to which the deflected flap from the left half of the lip is adjusted, the middle part being fitted into the retiring angle on the left side, as at *bc*, in Fig. 350. The pink membrane must be cleanly and entirely removed, for if any of it be left primary union at that spot is impossible. It should be removed from around the entire thickness of the lip so that the approximated raw surfaces may be wide and serviceable. Not a particle of the skin, however, should be sacrificed. (The sketches illustrating the scheme of the operation are purely diagrammatic; each case requires some modification.) This operation resembles Mirault's[4]

FIG. 349.—MUCOUS BORDER REMOVED FROM RIGHT SIDE (*b*), FLAP (*a c*), CUT FROM LEFT SIDE.

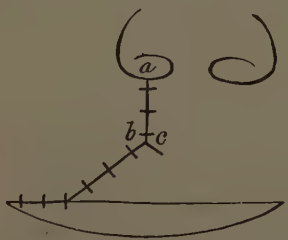


FIG. 350.—FLAP FROM LEFT SIDE, ADJUSTED ALONG RIGHT SIDE OF LIP.

in that a flap is brought across the fissure, but his operation consisted in cutting with a pair of scissors a small flap from the lower border of the lip which was to be arranged to form a normal prominence for the lip. The flap measured but ¼ inch and it hung from the border of the lip by a sort of pedicle. This is very different from the massive piece which is carved out of the lip in the manner just described. Stitches should be inserted not only down the front of the lip but also on the dental aspect. Some of them should be placed very deeply, so as effectually to prevent the halves of the orbicularis and the associated muscles from dragging upon the wound. Prepared horsehair may be used for adjusting the edges of the skin and for securing the transplanted flap along the opposite half of the lip. Silk is not a suitable material as it becomes swollen and septic. The raw *surfaces* themselves must be kept in close contact. This is effected by passing some of the posterior stitches very deeply and boldly with a curved needle, the needle being brought almost through to the skin. These stitches are of great use in steadying the flaps and promoting prompt union.

Hare-lip pins should not be used even in operations upon the very worst cases. Not infrequently the spots at which they traversed the

skin are permanently marked by white scar-tissue. A great advantage of the deep sutures on the dental aspect of the lip is that they leave no mark. They arrest bleeding and they adjust the surfaces and edges of the wound so well that possibly only a few stitches may be required for the front. The stitches should not be fastened up too tight or they will cut their way out; they are wanted merely to hold the surfaces gently together. The ends should be left about ¼ inch long, so that they can be more easily seized by the forceps when the time comes for removing them.

To Improve the Nostril.—If the nostril be wide and flat it should be made shapely, and fixed in the approved position. Some of the cartilaginous ring may have to be cut away so as to reduce its size and round it off. It may have to be first separated from the bone, and it may be advisable to hitch up the lower and outer part of the nostril by a wire suture. In some cases it is well to turn up the mucous membrane and then, having shaved off a thickish slice of the cartilage, to bring down and suture the membrane.

As soon as the last stitch is inserted and the face washed and thoroughly dried, the assistant should purse up the lip with the finger and thumb while the surgeon applies the dressing, a strip of gauze dipped in collodion and long enough to reach well on to the cheeks. Next day this had better be removed, and it is often advisable to do this dressing under chloroform. The nurse pushes the slack of the cheeks toward the middle line and the surgeon peels the ends of the gauze by pulling them *toward* the area of operation, so as not to drag upon the sutures. Then, when the wound has been cleaned, the surgeon may decide to remove, perhaps, every other stitch, as the edges of the wound are closely adhering. If a large stitch has been deeply inserted from the front it certainly ought to come away lest it should leave a scar, and the sutures up by the nostril may also be ready for removal. A gauze and collodion dressing is applied as before.

Next day or the next day but one the wound should be dressed again, a few more of the anterior stitches being removed, the posterior stitches being left. Thus, within four or five days all the visible sutures are removed, those at the tail end of the flap and at the free border of the lip being last dealt with. For ten days or a fortnight after this the lip must be kept free from disturbance by gauze and collodion, or by waterproof strapping. If the surgeon does not think it necessary to have chloroform administered for the dressings, the child's head must be steadily held by the nurse, or she may sit in a chair opposite the surgeon with the child lying on her lap, while the surgeon grips its head firmly between his knees.

When the intermaxillary bone and the prolabium have been sacrificed and the new lip is very small, the removal of a wedge-shaped piece from the middle of the lower lip may improve the appearance.

Double Hare-lip.—If the hare-lip is double and the prolabium has been left, it may need to be lowered somewhat before it can be

made available for the new lip. This being done, the mucous membrane should be thinly and cleanly dissected off its borders and the two sides of the lip should be arranged for blending with it. Probably one side of the lip, *b*, is larger than the other; this, therefore, should be chosen to form the prolabium and the lower border of the new lip. A flap is also cut from the other side of the lip, *c*. But before this is done the mucous membrane is peeled from its free border, so that the flap can be dovetailed in between the vivified border of the median bud, *a*, and the fresh-cut surface of the other flap, as shown in Fig. 351. If this flap, *d*, which is denuded on both its upper and its lower surfaces, is long enough it may be bent around the border of the median bud toward the opposite side, lying between the median bud, *a*, and the large flap, and in this position it is duly secured by a few deep sutures as described on p. 617, and by superficial ones of horsehair.

In some cases the median bud is so hopelessly out of place that it is unavailable for the repair of the lip, but by trimming off the sides it may sometimes be made to form a columella between the nostrils.

FIG. 351.—DOUBLE HARE-LIP, THE CHIEF FLAP BEING BROUGHT ACROSS FROM THE RIGHT SIDE.
a, Prolabium trimmed; *d*, small flap from left side denuded and ready for dovetailing.

Dyspnea after the Operation.—When the wide fissure of a hare-lip has been closed by operation, the child's breathing is necessarily embarrassed for a short time afterward; for, whereas the air-way had been unusually free, it is subsequently much lessened and the nostrils are apt to be a good deal blocked by dry blood and mucus. In these circumstances the nurse has to guard the child from suffocation by gently depressing the lower lip until he has accustomed himself to the altered conditions.

Probably the surgeon notices the dyspnea as he is finishing the operation and, if it is very marked, he may feel inclined to pass a suture through the back of the lower lip and bring the two ends round the border of the lip to fix them to the chin by a piece of waterproof strapping. The sucking in of the lower lip and the difficulty of breathing will thus be obviated, and as there is no tension on the suture it does not hurt the lip. This matter should be carefully attended to, for if after the surgeon had taken his departure the respiration became increasingly embarrassed and the nurse were not equal to the emergency the child might die of asphyxia.

A Notched Lip.—If the lower border of the lip be marked by a notch—either with or without an operation having been performed—the notch may be effaced by making a horizontal incision into the substance of the lip a little above the notch and by then closing the wound in the vertical manner. The operation is on the principle of the Heinecke-Mikulicz operation for pyloric stenosis (*q. v.*).

Failure of Union.—When, after a hare-lip operation, the surgeon

finds that all has "broken down," and that there is no chance of obtaining primary union, he may still hope for a good result by granulation. If the flaps fall apart the sutures should be removed and the lip should be bathed in warm boric lotion and covered with wet boric gauze. So long as the tissues are acutely inflamed nothing can be done with a view to bringing the parts together again; but as soon as the inflammation has subsided and healthy granulations begin to cover the raw surfaces, the sides of the lip should be readjusted by gauze and collodion or by strips of waterproof strapping. In this way a very excellent result may often be obtained for an operation which had threatened a hopeless breakdown.

Cleft Palate.—Development.—In early fetal life the buccal and nasal fossæ form one continuous chamber; at the eighth week a maxillary process grows inward from each side to form a partition between the fossæ. If these processes fail to meet, the gap in the palate should be in the exact median line. The front part of the hard palate, however,

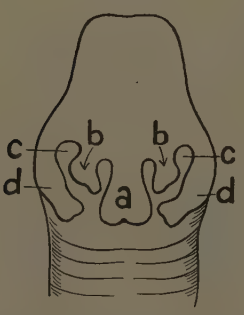


FIG. 352.—EMBRYO OF THREE WEEKS.
Showing frontonasal process, *a*, descending between the superior maxillary plates, *b b*; eyes, *c c*; inferior maxillary plate, *d d*.

FIG. 353.—CLEFT PALATE AND DOUBLE HARE-LIP.
Intermaxillary bones and prolabium attached to tip of nose (from a photograph).

is not developed from these processes, but, with the anterior part of the nasal septum and the median part of the upper lip, from a column of mesoblastic tissue descending from the frontal region. This tissue contains the intermaxillary bone. Thus the roof of the mouth is formed by the fusion of the maxillary processes with each other in the middle line and with the descending nasal process. A cleft of the soft and of the back of the hard palate is in the median line; but toward the front it passes outward and forward between the borders of the intermaxillary bone and the front of the maxillary processes, the line being Y-shaped. When failure of union between the median and the lateral processes affects the integumental parts as well as the bony, the cleft palate coexists with a double hare-lip.

From the frontonasal process are developed the intermaxillary bones, the vertical plate of the ethmoid and the vomer, and by the third month they should be united with the adjacent tissues.

Fig. 352 shows the oronasal cavity and the notched frontonasal

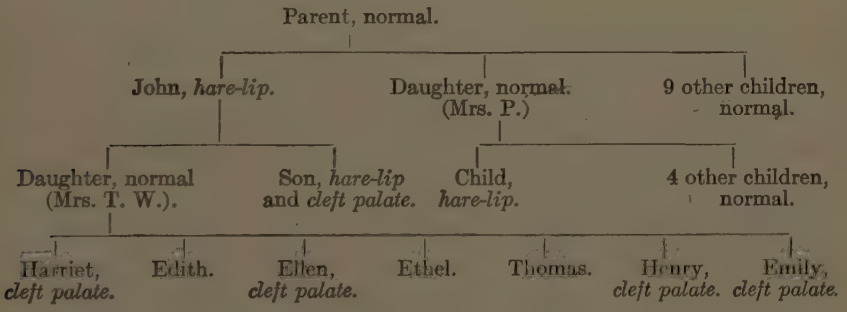
process, *a*; on the borders of the frontonasal process are the superior maxillary processes, *bb*, which blend with the frontonasal bud, to complete the upper lip. Thus, the fissure of the imperfectly developed lip is where the descending process should blend with the lateral fold; it is not in the median line. The fissures of a double hare-lip represent the notches which existed between the frontonasal and the maxillary buds of embryonic tissue. When the osseous tissues in the deep parts of the processes join, while the superficial parts do not, hare-lip exists without a palatine cleft.

Single hare-lip is more often upon the left side. It may vary in degree between a mere notch and a fissure extending up into the nostril. Sometimes there is a notch beneath each nostril or a fissure into one nostril and a notch beneath the other. Or there may be a fissure into each nostril, with isolation of the prolabium and the incisive bones, which may be attached to the tip of the nasal septum, as in Fig. 353.

The frontonasal bud is marked by a median notch and if this persists a *median hare-lip* may result. I have seen only one such case.

Maternal impressions have nothing to do with the causation of hare-lip or cleft palate. As a rule the supposed "fright" occurs after the lips are developed, which is in the ninth week.

Hare-lip and cleft palate sometimes run in families: here is an instance:[3]



If the descending frontal process misses its way it may join one of the lateral portions of the lip or, as already noted, the tip of the nasal septum (Fig. 353). A common variety of cleft palate is that in which the median fissure runs outward and forward on one side only—like a letter Y with one arm broken off. This is generally associated with a single hare-lip.

In most cases of cleft palate and hare-lip, that portion of the maxillary arch which is attached to the septum contains the central incisors, the lateral incisors being altogether wanting. Sometimes it contains the four incisors, the palatine fissure in those cases passing in front of the canine tooth. If the cleft be on one side only the maxillary arch will probably contain three incisor germs, the absent tooth being on the site of the palatine cleft.

Development of the Teeth.—Ossification of the maxilla and development of the teeth bear no relationship to each other. The teeth are formed from buds of the deep layer of the buccal epithelium, which, growing downward, become surrounded in due course by the bony alveoli of the palatal arch. The buds for the central incisors pass into the premaxilla; those for the canine tooth and for the molars pass into the maxillary process. The bud for the lateral incisor happens to be placed just over the gap which exists between the premaxilla (mesial nasal process) and the maxillary process, and, after the manner of the man who sits between two stools, its fate is apt to be unhappy. It may, by chance, work its way into the premaxilla or, perhaps, into the maxillary process, or (and this is more than likely) it may find no resting-place and may fail to be developed.

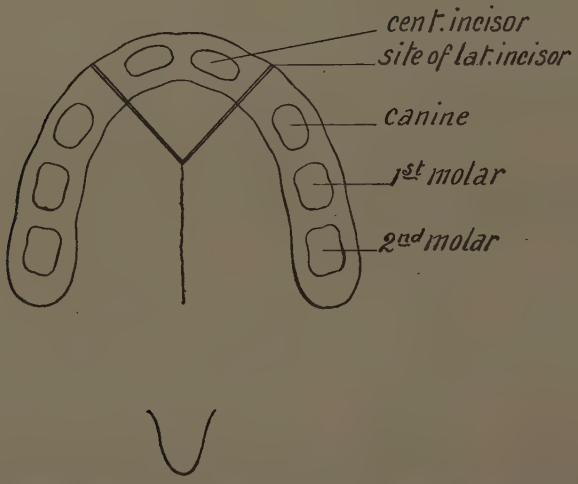


FIG. 354.—SHOWING THE SITUATION OF THE BUD FOR THE LATERAL INCISOR OVER THE DEVELOPMENTAL CLEFT BETWEEN THE PREMAXILLA AND THE MAXILLARY PROCESS.

Dr. Arthur Keith has shown the writer preparations in which the bud for the lateral incisor is attached to the very front of the maxillary process, standing forward from it into the cleft as a semi-isolated papule, and other specimens in which it is projecting into the cleft from the premaxillary mass. In rare examples the bud has evidently been split, a small lateral incisor being found on each side of the cleft. (Albrecht, in evolving his scheme, apparently confused the development of the teeth with the ossification of the maxillary arches.)

Mr. Clement Lucas has recently pointed out[5] that congenital absence of an upper lateral incisor or an imperfect development of that tooth in a parent is apt to be a forerunner of harelip or cleft palate in the offspring. Similarly, one may find a small lateral incisor behind the fissure of a hare-lip, suggesting that the child has narrowly escaped being the subject also of a cleft palate.

Age for Operating.—As cleft palate is an arrested development,

the gap ought to be closed at the earliest possible moment. *The most favorable time for operating on a cleft palate is between the age of two weeks and three months.* Dr. Brophy, of Chicago, affirms[6] that at this age there is less shock because the nervous system is rudimentary. The sooner the muscles of the soft palate can be made to work with a definite scheme of vocalization, the more perfect will the voice eventually become. When the operation is undertaken at a later age, though the gap in the palate may be completely closed, but slight improvement in vocalization may ensue. But if a newborn infant be badly nourished and ill suited for the struggle for existence, it would be wrong to submit him to any operation. He should be wrapped in wool, rubbed daily with cod-liver oil, and brought into a good state of health before the cleft is dealt with. As the limits of space render it impossible to consider all the various operations for cleft palate and hare-lip, the writer has had to content himself with describing those which he is in the habit of performing.

The Earlier Operation on the Palate.—Clear vocalization depends upon the anatomic integrity of the soft palate; the earlier, therefore, that a cleft is repaired the better. It should certainly be done before the hare-lip is operated on. For the closure of the cleft the radical operation of Dr. Brophy is advised. Briefly, this consists in thrusting the two superior maxillary bones together and then adjusting with sutures the vivified edges of the cleft. Brophy maintains that in cleft palate cases the roof of the mouth is excessive in diameter by just the width of the cleft, and that after the maxillæ have been thrust together and the palatine processes united, the development of the alveolar processes becomes normal, and that when the teeth of the superior maxillæ which have been shifted inward by the radical operation are erupted, they will exactly meet those of the lower jaw. One of the most important features of this operation is that the halves of the soft palate so brought together can be sutured without interference with the muscles of the palate, the prospects of securing a natural voice being thereby greatly increased. And just as the approximation of the hinder part of the maxillary processes gives assistance in the repair of the soft palate, so does the approximation of their anterior part simplify the subsequent operation on the hare-lip. The operation is begun by raising the cheek. A strong needle on a handle is then thrust through the maxilla, just behind the malar process, and above the level of the horizontal process of the palate bone. This needle carries a thick silk pilot-suture through to the cleft, and its loop is pulled down toward the mouth. Then the needle is similarly passed through the opposite maxilla, the loop being brought down as before. This second loop is passed through the first, which, being drawn upon, is made to bring the second loop out through the maxillæ and across the nasal fossa. The sharply bent end of a thick silver wire is then hooked on to this loop and by pulling on the latter the wire is made to take its place. The wire suture thus lies above the horizontal processes of the palate bones, where it

can be seen through the cleft. Similarly, a wire suture is taken through the maxillæ above the front part of the cleft. Two small, oblong leaden plates, with a hole drilled near each end, are then laid along the outside of the right maxilla, under the cheek, the end of the hinder wire being passed through the posterior hole and the end of the front wire through the anterior hole. The right ends of the wires are then twisted together from left to right, the plate being closely pressed against the maxilla, after which the twisted ends of the wires are flattened down. The ends of the wires under the left cheek are then similarly treated, and, as they are being twisted up, the maxillæ are squeezed together. If, however, they are too firmly fixed to be moved toward each other, the bones themselves must be divided by a scalpel

FIG. 355.—CLEFT PALATE AND HARE-LIP IN AN INFANT AGED THREE MONTHS.

sufficiently to enable the surgeon to force their palatine processes into the middle line. After this is done the width of the gap in the lip is greatly reduced and the lateral halves of the soft palate come close together. Wire sutures are then passed through the freshened borders of the entire cleft. When the maxillæ have been thrust together the wires extending between the leaden plates have to be tightened up. These wires and plates are not disturbed for three or four weeks. Some superficial ulceration may take place beneath or against the borders of the plates, but it is not of importance. The wires and plates may be removed after about the third week.

The Prolabium.—If the prolabium and incisive bone are advanced and isolated (Fig. 355) the surgeon may be unable to make use of them,

but it should always be his endeavor to do so. Sometimes the projection can be thrust into position only by bending down the tip of the nose, and when it has become firmly attached in its new position the connection with the nose may be divided. Sometimes after the removal of a triangular piece from the septum the prolabium will come usefully into position.

If later on the maxillary arch did not widen out sufficiently this could be easily made right. But even if it were found small, that defect would be more than counterbalanced by the fact that, owing to the approximation of the hinder ends of the maxillary processes, the surgeon had been enabled to form a soft palate without tension and without interfering with the tensor and levator palati. After operating by the old method one was apt to find the velum extremely tight, but, of course, it was not left in that condition. It was relieved

FIG. 356.—THE SAME INFANT SHOWN IN FIG. 355, THREE MONTHS LATER.

of tension by the method of Fergusson or Pollock or in some other way. Another plan is to make a free incision from before backward through the velum near its lateral attachment.

Children Beyond Infancy.—With regard to children beyond infancy, the operation should not be undertaken until the mouth and teeth, fauces and pharynx are brought into a healthy condition. Carious teeth should be extracted or cleaned and filled. Enlarged tonsils should be amputated and adenoids cleared away. For a day or two before the operation the nurse may wash the mouth with a hand-spray of some mild antiseptic, so that, subsequent to the operation, when its use is highly desirable, the child may not object to it.

The operating-table should be between 3½ and 4 feet high (inclusive of a firm mattress) and so narrow that the assistant may also be able to see into the mouth. The **instruments** should be laid

on another table of the same height, and should be arranged upon an aseptic cloth, from left to right, in the order in which the surgeon is likely to use them. They should not be placed in a lotion. The most convenient anesthetic is chloroform, given on a flannel mask, which, later on, is changed for a Junker apparatus.

The anesthetist should not be called upon to help in the operative work; he has enough to occupy his thoughts and his hands. The child ought to be only just "under": the anesthetist should be able to feel that at any moment, if need be, he could wake him up. The operator should not mind the patient making purposeless movements from time to time, as he then knows that his patient is "upon the safe side." It would be easy to give an overdose to a child in this operation.

Stoppage of breathing or a suggestive change of aspect should at once interrupt the operation. If artificial respiration is called for, the gag should be quickly removed and the child held up by the feet, so that blood may reach the anemic brain. With the child in this position the anesthetist swabs the face with cold water, and rubs it dry. Gently and slowly he compresses and relaxes the chest, so that the heart and lungs may be stimulated by the entrance of air.

Position.—The best position for the operation is upon the back, with the head hanging over the end of the table, so that the blood may escape by the mouth or nostrils. This position, however, sometimes hinders the breathing; still, it should be tried in every case. It often happens that after the operation the child vomits blood; and sometimes when there has been little or no vomiting the first motion passed after the operation is tarry, some blood having found its way into the alimentary canal in spite of the child's having been kept inverted during the operation.

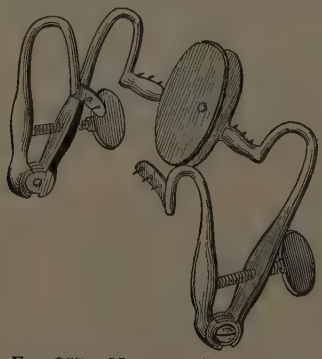


FIG. 357.—MODIFIED SMITH'S GAG.
(It is well to be provided with three sizes of the gag.)

FIG. 358.—TUBULAR MECHANICAL NEEDLE.

The Gag.—A perfect gag has yet to be invented. The writer generally uses a modified "Smith's gag," as shown in Fig. 357. The best palate knives have a long cutting edge and a thin back.

The *raspatories*, made of steel, should be slender and about eight inches long, with the ends in different curves suitable for variously pitched arches. The ordinary steel aneurysm needle makes a useful raspatory.

The *swabs* can be made of tufts of absorbent cotton loosely tied up in gauze. They should vary in size from a cherry to a plum and should be used dry.

The Needle.—The most convenient needle is the tubular one, with a reel containing an abundant supply of fine silver wire. At the end of the needle is an arrangement by which one of the curved, sharp points can be rigidly fixed; the wire is made to run through it by the movement of a small wheel upon the handle. The points are of various curves and sizes and, being round, do not cut the flaps.

Cleft Palate; the Operation after Infancy.—As already stated, the best time for operating on a cleft palate is within the first few weeks after birth. But it may happen that the child has passed that age when he is brought to the surgeon, so that the radical operation cannot be done. Assuming, then, that he is in a good state of health and that his mouth is clean, he is placed upon the table for operation. The child being under chloroform, the surgeon passes a long suture through the tip of the tongue and gently pulls it forward, so that when the gag is fixed the tongue may not block the air-way. A strip of mucous membrane having been removed from each side of the cleft, short incisions are made close to the teeth, passing down to the bone, as shown in Fig. 359.

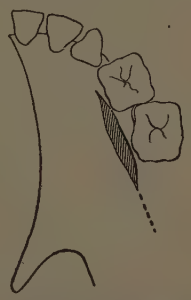


FIG. 359.—LEFT SIDE OF PALATE, SHOWING INCISION ALONG ALVEOLAR PROCESS, WITH DOTTED LINE IN WHICH IT MAY HAVE TO BE EXTENDED.

Bleeding is then checked by firm pressure with a dry swab. The closer that these incisions are made to the teeth the less the chance of wounding branches of the descending palatine arteries, the broader will be the flaps, and the less the likelihood of their blood-supply being seriously interfered with. Then, by raspatories introduced through these incisions, the muco-periosteum is detached from the hard palate. The higher the pitch of the roof the greater is the probability of the flaps being brought together without tension. Indeed, in some cases of high roofs the flaps are so slack that not only their bare edges, but some of their raw upper surfaces can be brought together. And this increases the chance of securing prompt union. But they do not often come together without tension; this is because they are continuous with the velum, which is firmly connected with the hard palate. In the velum is an aponeurosis, which, attached to the border of the hard palate, receives part of the insertion of the tensor palati

and the levator palati, and this aponeurosis must be detached before the velum can be moved inward. Success largely depends upon the the thoroughness of this disconnection.

It is best secured by passing one blade of a pair of scissors (bent on the flat almost to a right angle) between the detached muco-periosteum and the under surface of the back of the hard palate, and the other through the cleft and over the back of the velum, as shown in Fig. 360. Thus between the blades are placed the mucous membrane which is continued from the floor of the nasal fossa and the aponeurosis of the soft palate, together with that part of the tendon of the tensor palati which is inserted into the palate bone. When this scissors cut has been made the muco-periosteum and velum hang loose and the flaps are ready for suturing.

Having passed the sutures through the flaps, the surgeon may find so much tension upon the edges of the flaps that he deems it best to twist up the sutures but loosely. Later, when he has increased the length of the lateral incisions, he may tighten them up permanently with torsion-forceps. And so that he may know in which way he should twist to tighten he should make it a rule always to twist from

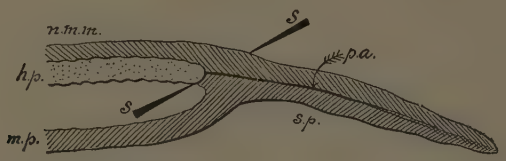


FIG. 360.—DIAGRAMMATIC REPRESENTATION OF JUNCTION OF (*h. p.*) HARD AND (*s. p.*) SOFT PALATE.

m. p., Muco-periosteum detached from hard palate; *n. m. m.*, mucous membrane from floor of nares; *p. a.*, aponeurosis of soft palate; *s. s.*, blades of curved scissors about to cut through the aponeurosis and the membrane.

left to right, as in winding a watch. If it be found that, as the flaps are drawn together, there is so much tension that if the silver sutures were fully twisted up either the wire would break or cut its way through the flap, he must prolong the incisions backward into the halves of the velum. The course of this prolongation is shown by the dotted line on Fig. 359. The incisions thus made sever the aponeurotic insertion of the tensor palati and the chief part of the insertion of the levator palati.

However wide a cleft of the hard and soft palate may be, it is advisable to operate upon the entire cleft at once rather than to divide the operation into two parts, one for the hard palate and one for the soft.

In certain cases of wide cleft of the hard palate of a grown child the bone may be cut about $\frac{1}{4}$ inch from the gap on each side and the flaps of bone and mucous membrane shifted together, the vivified edges being adjusted by sutures.

After-treatment.—On the completion of the operation the child should be so placed that the saliva, blood, and mucus may dribble out of the mouth. In the case of an infant the nurse had better keep

him in her arms for a while, with the face directed downward. But if he is too big to be thus held, he should be put in the half-sitting position and partly turned to one side, with the head bent down, so that the saliva may dribble into a towel. If the child is collapsed it may be necessary to keep his head quite low and to give an enema of hot water with a little brandy. The child should have nothing by the mouth for several hours, but when the nausea has apparently passed off small quantities of beef jelly may be given in a teaspoon. This may be supplemented by rectal feeding. Jelly slips down easily, and is preferable to milk; it does not form curds in the stomach and is easily absorbed. In the course of a day or two a little sweetened orange-juice, chicken or meat which has been run through a fine sieve, bread and milk, or a soft custard pudding may be given. Home-made beef-jelly, chicken broth, and all other foods for children are far better than the various meat-essences, extracts, and juices supplied by the shops.

If the child will allow the nurse to spray the mouth into a basin so much the better, but it should not be persisted in if it frightens him. As regards the lotion for irrigation, listerine, sanitas, Condy's fluid, or boric acid with glycerin answers well. It is unnecessary for the surgeon to remove the sutures; they will quietly ulcerate their way out. This refers, of course, only to the fine wire and horsehair sutures, not to those more solid ones of silver wire which pass through the maxillæ and the lead plates in the radical operation of infancy (p. 624).

Should severe **hemorrhage** occur, the gag must be reintroduced and search made for the bleeding vessel. All clots should be removed and the mouth and nasopharynx should be syringed out with warm water, the head being in the overextended position. This might suffice to arrest the bleeding. If it did not, and the bleeding was seen to be from one of the lateral incisions, a long strip of gauze dipped in a solution of adrenalin should be gently stuffed through the gap, and to the back of the velum, and the soft palate should be gently thrust up against this packing by means of a dry pad of gauze on a holder.

Suppuration Threatening Failure.—If septic inflammation attacks the wound the child looks ill and yellowish, his temperature goes up, and his breath becomes foul; still, the operation need not prove a failure. Some part of the cleft is generally closed and granulation tissue in due course closes more. As soon as healthy granulations cover the surfaces (which will be in about a fortnight) the child will probably have undergone auto-immunization, and the operation may be done over again with a good prospect of complete success.

A perforation remaining after a not entirely successful operation may of itself close with time. A hole as large as a pea may be left in the hard palate after the performance of an otherwise successful operation. The introduction of the slender blade of a thermocautery will complete its obliteration. The narrower the cleft and the earlier

the date at which it is closed, the more perfect will be the speech; the closure of a wide cleft in late childhood brings but slight improvement to the voice. Amelioration greatly depends upon the attention which the parents devote to teaching the child to pronounce distinctly. The child should be shown the movement of the lips and tongue of the teacher when the difficult words are being pronounced, and he should be made to imitate them over and over again. A person accustomed to teaching deaf-mutes would give helpful instruction.

Other (acquired) malformations of the palate may result from the adhesion of apposed surfaces which have been left raw after surgical operations, as well as by the contraction of cicatricial bands into which granulations have been developed after burns, scalds, ulceration, or sloughing, or after the removal of extensive buccal nævi. As an example of the first may be given the adhesion of the fresh stump of an amputated uvula to the posterior wall of the pharynx left raw after an operation for adenoids. The operative treatment of *intrabuccal contractions* is generally disappointing, for the granulation tissue which fills up the gaps left after bands have been divided becomes converted into a new material which undergoes a similar condensation and contraction.

Terrible *deformities* often occur *after burns of the face and lips.* It has been said that the scar-tissue following a burn undergoes greater contraction than new tissue formed in other circumstances; the explanation probably is that the scars left after burns are apt to be extensive and deep. Thus, the mouth may be reduced to an opening the size of a pea, the lower lip may be everted and drawn down to the chin, and the chin itself may be fixed to the front of the sternum. The irresistible pull of contracting adhesions may cause eversion of the lower teeth and serious deformity of the jaw. The deformity of the mouth left after syphilitic ulceration is not so great as that following a severe burn. For the treatment of these conditions see the chapter on *Plastic Surgery*, Vol. V.

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THE LIPS, PALATE, AND CHEEK.

The lips consist of a mass of striped muscular fiber and connective tissue covered with skin and lined with mucous membrane, which is continuous with that of the gums and mouth.

Inflammation of the lips may be either acute or chronic. The former condition is likely to be due to infection by staphylococci or streptococci and may vary in degree from a localized cellulitis, which passes off quickly or ends in suppuration, to an erysipelas which, spreading to the face or neck, may end fatally.

Chapped Lips.—The mucous membrane covering the free border of the lip is thin and delicate, and is kept soft and pliant by the moisture of the mouth and the mucus which is secreted by its own glands. Under the influence of cold, drying winds, the moisture is carried away and the surface is apt to crack. The crack extends from before backward, and when the person laughs, or in any other way stretches the lip, the exposed filaments of sensory nerves are irritated and the capillaries opened. Time after time this happens and the crack becomes a chronic ulcer with a thickening at its base, and, after the manner of a fissure of the anus, may be the cause of much distress.

To prevent the occurrence of chapping the surface of the lip should be frequently smeared with glycerine or cold cream. If a sore refuses to heal under such treatment it may be painted with a solution of cocain and touched with a point of nitrate of silver. But if it should prove unusually obstinate the ulcer had better be dissected out in the base of a slender wedge, the sides of the wound being brought together by a few fine sutures, and the linear wound covered with flexible collodion.

Chronic inflammation of the upper lip is often met with in tuberculous children and is caused by the irritation of discharges from the nostrils. The lip becomes thick, red, and prominent and is liable to ulceration. It may also be found as a secondary affection in persons with tuberculosis of pulmonary or other tissues. Cases are on record in which the bacilli of tuberculosis evidently obtained entrance into the lip through a wound caused by a tooth or a fork.

Lupus may begin on the lip or spread there from the cheek or nose.

Chronic inflammation of the lips of a vesicular (eczema) or pustular nature (impetigo) is often met with in unhealthy children; it is apt to cause enlargement of the cervical lymphatic glands.

Treatment.—The child should be carefully dieted and given a mixture of rhubarb and soda, fomentations of boric acid lotion being applied under an impermeable dressing. Subsequently a course of iron and cod-liver oil may be advisable. *Herpes labialis* is a local inflammation of the surface of the lip, associated with the appearance of a crop of vesicles which burst and run together, giving rise to a superficial ulceration. The condition is found in gout, pneumonia, fevers, and other disordered states.

Ulcers of the lips may be due to syphilis, tuberculosis, septic infection, or injury. If an ulcer is allowed to become chronic the epithelial cells about its base are apt to penetrate deeply and eventually to convert an innocent sore into a cancer.

Epithelioma of the lips is generally due to chronic irritation in persons beyond middle age, and the commonest cause of it is a tobacco pipe or a prominent, jagged tooth. The most harmful sort of pipe is that of baked clay which the smoker is in the habit of breaking off short; the wet epithelium clings to the absorbent clay and is peeled off the lip when the pipe is removed. This leaves the mucous membrane denuded and sore, the inevitable result being a slight local inflammation.

When this little injury has been occurring in the same spot time after time during a long course of months or, possibly, of years, a permanent local thickening of the lip takes place, but inspection might fail to discover clear proof of malignancy. There is a slight but obstinate abrasion of the surface with some moist discharge, without enlargement of submaxillary lymphatic glands; but if the irritation be allowed to continue the signs of malignancy soon become manifest. It is in this stage of the disease that surgery can do so much: if the irritated tissue is removed by the knife prompt healing takes place, and pipe-smoking being given up, or the troublesome tooth being removed, the clinical episode is soon forgotten.

If the piece which has been early taken away be examined microscopically, it shows enlarged papillæ with the epithelial cells all upon the proper side of the basement membrane—a sure sign of innocency; but if, as too often happens, a belated operation has been resorted to, the epithelial cells are seen passing between the papillæ into the substance of the mucous membrane—unmistakable evidence of malignancy. The clinical signs of the malignancy of the growth would be its painless, indolent nature, its refusal to heal, and its hardness. Assuming that the sore is on the lower lip (which is by far its more common seat) and in a man (women are very rarely attacked), careful search should be made for enlarged glands below the jaw, especially for one just beneath the symphysis. It is not always an easy matter to find them, for they do not stand out as in the case of primary syphilis or of a septic sore. The best way to examine for them is for the surgeon to place himself behind the patient and to get him gently to bend his head forward so as to relax the tissues at the front of the neck. The mass is not tender, and on gently compressing it between the finger and thumb soft plugs of epithelial débris may be squeezed out. If the epithelioma is allowed to grow unchecked, it finds its way to the gums and sets up firm connections between the lip and the bone.

The **diagnosis from hard chancre** is effected by the length of history, the dry, quiet appearance, the absence of sore throat, of secondary eruptions, and of the large submaxillary buboes.

Operation.—To excise an epithelioma of the lip without opening up the submaxillary region and clearing away the associated lymphatic glands is to invite disappointment. For the glands contain epithelial growth almost as surely as did the labial sore, and if they are left it is but a question of time when they will involve the neck in malignant ulceration. They should be dissected away whether they are apparently enlarged or not: the simple operation of the removal of a wedge from the lip is a thing of the past. Free excision of labial cancer by the knife has this great advantage over treatment by *x*-ray, and over all other bloodless measures, that the surgeon is able at the same time to rid the patient of the deposits in the glands. In every case of operable epithelioma of the lip a radical operation should be done. Some operators [1] make it a rule to tie the facial vessels and then remove the submaxillary salivary gland and the lymphatic glands, together with

all the lymphatic elements from one angle of the jaw to the other, as well as the glands over the carotid bifurcation. But if the epithelioma has a lateral situation it may be necessary to clear out only the corresponding submaxillary and carotid region. Even if the growth seem to be so adherent or widely spread that operation can offer the surgeon but a poor hope of being able to get it all away, still the writer would be in favor of making the trial. It not seldom happens that when a surgeon has proceeded some distance with an operation, difficulties which had before seemed well nigh insurmountable are vanquished, and it is completed with satisfaction. An operation such as this may entail the surgeon's shaping out a new lip from the thickness of the skin of the face or neck (see *Cheiloplasty* in Chapter on *Plastic Surgery*, Vol. V.).

Dowd's operation (Fig. 361) meets the requirements of most cases, especially the extensive ones, better perhaps than any other. By it practically the entire lower lip may be removed with but little deformity, and the glands can be removed at the same time. The incisions next the growth should be placed so as to remove 1.5 to 2 cm. of sound tissue with the tumor. As much of the skin over the prominent part of the chin as possible should be kept. Horizontal incisions from the angles of the mouth about 5 cm. long should be made before removal of the tumor, so as to insure symmetry. They should be carried only down to the mucous membrane. This should be divided about a centimeter higher in the inside of the cheek and used to form the vermillion border of the lip. Should the jaw be involved, all of the diseased portion and somewhat more should be removed.

FIG. 361.—DOWD'S INCISION FOR REMOVAL OF EPITHELIOMA OF LOWER LIP AND THE GLANDS. (Keen and White.)

Angiomata.—Nævus of the lip may be either capillary or venous. The former may be situated upon the cutaneous or the mucous surface, or it may reach to both surfaces. A *venous nævus* may bulge upon either aspect of the lip or may extend right through its substance. It should be dealt with promptly, as in this situation it is apt to grow rapidly. It may be treated by electrolysis. If it is large and well defined it had better be removed by dissection, the vessels of supply being included in the sutures which bring the surfaces of the wound together.

A **labial cyst** may be produced by the distention of one of the small mucous glands. It stands out upon the dental surface of the lip as a translucent bead. It is best treated by entire removal under cocain, the edges of the incised wound being brought together by fine sutures.

Horny elevations may result from an epithelial deposit drying upon the surface of some enlarged papillæ. In rarer instances they are due to a piling up of dry material upon the shell of a sebaceous cyst. They should be treated as has just been advised for labial cysts.

Macrocheilia (hypertrophy of the lip or lips) is the result of congenital dilatation of the lymph-spaces (*cf.* Vol. II., p. 607). There is, in addition, a considerable formation of new fibrous tissue, and sometimes the capillaries and veins are dilated as well as the lymphatics. When the lower lip is affected its weight may cause it to hang down and to be everted. If the affection is slight it may be remedied by electrolysis performed from the mucous aspect. This has the effect of destroying much of the overgrowth and of replacing it by an interstitial granulation tissue which, undergoing contraction, squeezes the adjacent spaces empty and causes a general shrinking. If, however, the enlargement is great, a wedge-shaped piece must be removed from the entire thickness of the lip transversely and the upper and lower sides of the gap fixed together by sutures.

Malignant Pustule.—(See Anthrax, Vol. I., p. 503.)

Noma (Cancrum Oris).—(See Vol. I., p. 344.)

Carbuncle.—(See Vol. I., p. 258.)

Of **wounds** and **injuries** of the lips the most common are cuts and contusions, either of which may involve serious bleeding from the coronary artery. (On everting the lip the bleeding point may be secured by a stitch.) Contusions of the lip against the teeth may be followed by much swelling, especially of the mucous membrane. Flames ascending from the burning clothes and the accidental or criminal contact of caustic fluids may cause extensive sloughing of the lips, with subsequent deformity of the mouth.

Stings or **bites** may cause much edema, and if the bite happen to be made by a fly arising from infected meat the result may be alarming or even fatal.

The best application to an ordinary sting is *sal volatile*. If the wound has been inflicted by a fly which has arisen from a germ-laden hide or carcass, carbolic acid or some other effectual cautery should be applied.

Stomatitis.—Inflammation of the mucous membrane of the mouth may be of a simple catarrhal nature, clearing away by itself or with the help of a boric wash. In children a parasitic form, *thrush*, is common enough. *Oïdium albicans* is the vegetable growth to which it is due. The feeding-bottles should be looked to, and the white patches should be painted over with boric lotion.

In unhealthy children stomatitis may run on to ulceration with hemorrhage (see Scurvy and Rickets, Vol. I., pp. 574 and 580).

Gangrenous stomatitis is the result of the inoculation of virulent microörganisms, and will need the adoption of vigorous measures (see *Cancrum Oris*, Vol. I., p. 344).

Ludwig's Angina.—(See Vol. I., pp. 262, 346.)

Syphilis, as Affecting the Palate (*cf.* also Vol. I., p. 707).—

When a practitioner desires confirmatory evidence of a person's having been the subject of syphilis, one of the first things that he does is to inspect the palate for marks of former ulcerations, the palate being a favorite spot for attack in the later stages of the disease. Hunterian sores are occasionally found there, and very frequently the "mucous patches" of the secondary stage of the disease. The granuloma of the tertiary stage (gumma) is often seen in the bone or the mucous membrane of the hard palate and also in the soft palate. It is generally in the middle line and far back. Mr. Hutchinson says that perhaps in ninety-nine cases out of a hundred ulcerative destruction of these parts, if not cancerous, is syphilitic.[2] The case which forms the exception may be lupus. Ulceration of the palate often leads to necrosis of the superior maxilla and to wide perforation into the nasal fossa. Sometimes the uvula and the chief part of the velum are destroyed thereby. If the ulceration extend from the border of the soft palate to the pharynx and then, under the influence of iodid of potassium, begins to heal, the granulations of repair from the two surfaces may eventually blend. Subsequently they are converted into fibrous tissue which, in contracting, draws the remains of the soft palate into permanent contact with the pharynx. Such adhesions are very difficult of effacement. They must not be touched while the disease is still in progress, but subsequently they may be dealt with by incisions and sutures, the operations are likely to have to be repeated. Perforations of the hard palate may be dealt with as described in the treatment of cleft palate (p. 627) or by the application of an obturator. Perforations of the palate may result also from congenital syphilis when other manifestations of the congenital disease may be conspicuously absent.

The writer has known it to happen after an extensive operation for clearing the nasopharynx, finishing up with the amputation of an elongated uvula, that the stump of the uvula has formed firm adhesions to the back of the pharynx. One should make it a practice, therefore, not to amputate the uvula at the same time that he removes adenoid growths.

Lupus may attack the palate, but its progress is much slower than syphilis. As Mr. Hutchinson says, "Syphilis may destroy as much in a month as lupus will do in years," and the patch of lupus on the palate is not likely to be the only one. When vigorously dealt with by spoon and cautery the places may with difficulty be made to heal, but the administration of iodid of potassium has no permanent influence upon them.

Emphysema of the cheek may follow a fracture of the antrum, the frontal sinus, the nose, or any neighboring part of the air-passages, and its presence implies that the mucous membrane has been torn.[2] When the individual coughs, sneezes, or vigorously blows his nose, air is forced into the connective tissue where it may be recognized by the fine cracklings which are felt under the gentle pressure of the finger. No active treatment is needed.

Inflammation of the palate may follow the implantation of

septic germs, as after operations, or it may be part of a general stomatitis, as described on p. 634. In those who smoke a great deal, especially in cigarette smokers, a marked hyperemia of the mucous membrane of the palate and pharynx may be noticed. This should not be mistaken for inflammation.

Tumors of the hard and soft palate may be innocent or malignant; in the latter case the cervical lymphatic glands are likely to be enlarged. Among the innocent tumors are adenomata, cysts, nævi, lipomata, and fibromata.

With regard to malignant growths, the most important question concerns the possibility of removing them. Before coming to a decision it will be well to examine under an anesthetic, so that the finger can make a deliberate and thorough exploration of the parts, finding to what extent the growth is fixed and the amount of lymphatic invasion in the neighborhood. No operation short of a complete removal should be undertaken.

The commonest malignant tumor of the palate is epithelioma, which may be started by a badly fitting denture, a carious tooth, or any other source of chronic irritation. It begins as a wart or as an indolent ulcer with hard edges; it slowly increases in size, spreading to the gum or the tonsil, and causing induration of the lymphatic glands near the angle of the jaw or in the upper part of the neck. It is prone to bleed.

Sarcoma of the palate is likely to start in connection with some of the gland tissue, the growth being, thus, an adenosarcoma. It increases in size steadily, but slowly, and may at last hinder respiration as well as deglutition. Its covering of mucous membrane remains long unulcerated. Adenosarcoma occurs in youngish people; epithelioma of the palate is met with late in life. Although sarcomata of the palate must be placed in the malignant class, they nevertheless are not diffuse, they rarely implicate the lymphatic glands, and they do not usually recur after removal. They ought to be thoroughly removed at the earliest possible moment.

Hypertrophy of the uvula may be the cause of a distressing cough and of vomiting; these troubles disappear as soon as the uvula is amputated. The writer has seen a minute, unsuspected epitheliomatous ulcer upon the uvula giving rise to an enlargement of the cervical glands remarkable for its size.

THE TEETH AND GUMS.

Attention has already been directed to the necessity for rendering the mouth as aseptic as possible before performing any cutting operation upon the palate or tongue (p. 615). And inasmuch as respiration and deglutition place the air-passages, the gullet, and the stomach in active communication with the mouth, the surgeon should insist upon securing cleanliness of the mouth before operating upon any part of the air-passages or upon the esophagus or stomach.

Dental caries is a quiet disintegration beginning on the surface

of the tooth; it is caused by septic germs. By subjecting extracted (dead) teeth to the influence of these germs, "with imitation of the conditions existing in the mouth as to temperature and moisture,"[3] caries can be exactly reproduced. Caries, unless checked by art, advances toward the pulp-cavity and converts the tooth into a friable shell. The disintegrating process becomes painful as soon as the dentin is involved, and the pain becomes intense when the central chamber is laid open and the pulp is exposed to the action of external irritants and injury. Caries, however, is not the only cause of *tooth-ache;* in some cases it is due to the presence of diseased roots or to impacted wisdom-tooth; but it is generally of local origin (see Neuralgia of Fifth Nerve, Vol. II., p. 695).

FIG. 362.—COMMENCEMENT OF FORMATION OF CAVITY OF DECAY IN ENAMEL. (Leon Williams.)
Delay apparently arrested at line of stratification.

The starting-point of caries is a defective spot in the enamel, which may have been congenital or may have been caused by the influence of acids derived from the putrefaction of particles of food lodged in the crevices between the teeth. Through these spots the germs enter. Cocci and bacteria abound in the dentin-tubes or pulp-cavity of every carious tooth. The hollowness of a carious tooth is due to the fact that the dentin is more readily destroyed by the acid-producing germs than is the enamel. Overcrowding of the teeth is a great incentive to caries, in that it places particles of decomposing food beyond the reach of the brush and the tooth-pick.

Alveolar abscess has as its starting-point a carious spot about the fang of a tooth. The septic germs find their way thence into the peridental tissues and set up in them localized abscesses, the tension

often giving rise to throbbing, and to distracting pain. Sometimes the pus travels up by the side of the tooth and so effects its escape, or it may remain locked up for a while beneath the mucous membrane and thus give rise to a *gum-boil*.

In other cases the germs enter the alveolar process and set up an osteitis which may end in suppuration (alveolar abscess) or in necrosis.

Suppuration having occurred, the pus may work its way beneath the mucous membrane until the abscess "points" externally by the angle of the jaw, involving an ugly depressed scar, or the suppurative process may extend into the substance of the maxilla and give rise to abscess of the antrum. In every case of gum-boil or of alveolar abscess the place must be thoroughly exposed and cleaned, mild

FIG. 363.—SHOWING FORMATION OF INTERNAL CAVITIES AND DEGENERATIVE CHANGES IN THE DENTIN. (Leon Williams.)
Caused by penetration of the acid of decay, previous to any breaking down of enamel.

carbolic washes or solutions of peroxid of hydrogen being used. Subsequently, with the view of preventing further suppurative troubles, the septic focus in the tooth should be dealt with by the dental surgeon. In many cases the best treatment is the prompt extraction of the offending tooth.

Pyorrhœa alveolaris (Rigg's disease) is primarily a local affection, and is due to the action of various groups of septic micro-organisms upon secretions and particles of food lodged in pockets of the gums around the alveoli. Thus favorably placed, the germs set free a material which, being taken into the blood, gives rise to symptoms of slight, grave, or even fatal intoxication, according to its degree of virulence.

Mr. Goadby has carefully studied this disease in England,[4] as Rigg and Kirk have done in America.[5]

The pus may be found by pressing upon the surface of the alveolus, or it may be seen welling up of itself; sometimes it is difficult of discovery or is overlooked. The subjects of this disease (which may exist in a very chronic form) complain of general ill health, of obscure rheumatic pains, of headache, of slight but continued gastric troubles, and, as a general rule, of diarrhea or constipation. They have a gray appearance under the eyes. There is a reduction of red blood-corpuscles and hemoglobin, with a slight leukocytosis; sometimes purpuric rashes appear. Commonly a well-marked acne is present which may be pustular, and in some cases septic arthritis occurs. The gums are foul, hyperemic, and swollen; the walls of the alveoli are absorbed in due course and the teeth fall out—such devastation working the cure. But, unfortunately, the disease may spread from socket to socket until at last every tooth is shed. It is said that the disease is particularly apt to occur in gouty subjects. The cases are probably of a *mixed infection*, the microörganisms chiefly concerned being the various staphylococci.

Treatment.—A thorough inspection must be made of the mouth. The tartar should be removed from every tooth; all hopelessly decayed teeth should be extracted, and those which are not so far gone must be cleaned and filled. Loosened teeth must be made secure or they may be needlessly sacrificed. The pus-containing pockets in the gums must be opened up, scraped clean, and treated with some trustworthy antiseptic, and sinuses running from them toward or into fang or bone must be efficiently dealt with. If the condition has been acute, or is of long standing, search should be made for abscess in the bone and for sequestra. In short, this serious condition must be treated on those precise surgical lines which are followed when septic microörganisms are lurking in other crevices.

Mr. Goadby has treated chronic cases of this disease by Professor Wright's method of vaccination (Vol. I., p. 174). Briefly this consists in determining the relative value of the patient's serum as compared with that of a normal individual in promoting the ingestion of the given species of bacterium by the phagocytic white corpuscles. The average number of cocci ingested by a number of white cells is calculated in each case, and the ratio of the two averages gives what is known as the "opsonic index" for the special organism tested. Goadby is of opinion that amelioration in the general symptoms took place under the vaccine treatment, and in those cases in which the blood count was made a concomitant improvement was observed. He says that the patients expressed themselves as "satisfied" with the injections, and that in several instances they put on weight and lost the feeling of fatigue. But the difficulty in connection with such treatment will be to know in each case exactly which are the particular bacilli concerned and, therefore, in preparing the precise form of vaccine

desired. In the experience of the writer the vaccine treatment of this disease may be attended with remarkable success.

Replacement of teeth which have been temporarily removed, extracted in error, or violently knocked out, is a recognized operation. For its successful accomplishment three points must be attended to: first, the tooth and the socket must be aseptic; second, there must be absence of severe inflammation; third, the replaced tooth must be kept steady—much as a transplanted tree is steadied by a stake until it is well "established." Supposing that with some special object in view, or by an accidental slip of the forceps, a dental surgeon has removed a tooth which is in a condition for replacement, he cleans it to the extent of rendering it aseptic and then straightway puts it back in its place. But if from a blow of a fist, a kick from a horse, or some such violence, a tooth has been knocked out, perhaps to be picked up from the ground, or carried about in a pocket for some time before the case comes under the care of the surgeon, it would be unwise to attempt immediate replacement of the tooth even after making it aseptic. The injury which knocked it out must needs be followed by local inflammation and the tooth should not be put back until this has subsided. Having been carefully cleaned, the tooth should in the meanwhile be preserved in a warm and mild antiseptic solution, and in a few days time, when the inflammation has subsided, the socket should be washed and dried and the tooth gently pushed home once more.

The probability is that the tooth is one of the incisors, and as soon as it is in position a cast must be made and a gold plate molded from it, which, while taking its bearings from the tooth on either side, caps the replanted one and shields it from disturbance while it is fixing itself in position. It will be advisable to have this splint worn for at least three months.

Extraction of teeth may have to be performed if they are erupting badly, are hindering the due eruption of others, if they are crowded together, are in a hopeless condition of caries, or are lodged in a suppurating alveolus (see Pyorrhœa Alveolaris, p. 638).

The instruments by which extractions are usually performed are forceps and elevators, made of steel, and duly sterilized by heat. Before proceeding to the extraction, the surgeon should consider well exactly which teeth are to come out, and in the praiseworthy endeavor to be quick over his work he must look to it that he does not attack a wrong one. A great secret in the art of extraction is to thrust the blades well down into the socket, so as to be sure to close them upon a sound part of the tooth and not upon the hollow crown. A beginner who contents himself with gripping the exposed part of the tooth is likely to break it short off at the level of the gum, with the result that the subsequent extraction of the fangs is rendered difficult.

There is a wide choice of forceps for the various teeth, but the practical surgeon has generally a few favorite pairs with which he does most of his work. The use of the elevator is chiefly confined

to the extraction of the hinder molars, especially when, from the fixation of the jaws (p. 653) or from some other cause, the forceps are not serviceable. The operator must see well to it that when he has extracted a tooth or a root it does not get adrift into the pharynx or, still worse, into the wind-pipe.

Hemorrhage after extraction generally stops by itself, but in certain exceptional cases and especially in hemophilic individuals it may be extremely serious. Treatment may be begun by gently washing or syringing with warm water so as to remove the clots. Next, the empty socket may be covered with a pad of cotton-wool which is thrust into position by the firm closure of the jaws. If the bleeding still continues, adrenalin may be applied upon a small dressing of cotton-wool. Strong chemicals, such as the salts of iron, had better not be used, lest they should cause sloughing of the gum.

FIG. 364.—MALIGNANT EPULIS (FIBROSARCOMA). (Prof. Robert D. Murray, I. M. S.)
Woman aged thirty-five.

FIG. 365.—THE SAME PATIENT SHOWN IN FIG. 364, AFTER OPERATION.
The patient has been fitted with artificial teeth.

Odontomata are tumors composed of dental tissues in varying proportions arising from teeth-germs or from teeth still in the process of growth. They are named according to their origin from the enamel-organ, the tooth-follicle, the papilla, or the whole germ. The subject of odontomes has been much simplified by the able and original work of Mr. Bland-Sutton[6] (see *Tumors*, Vol. I., p. 784).

Gingivitis (inflammation of the gums) may be part of a general stomatitis which has been set up by septic inoculation, or it may occur in the course of pyorrhœa alveolaris; it may be a manifestation of scurvy or rickets, or may be the result of absorption of such drugs as mercury, lead, or phosphorus. The gum is red and swollen (especially in the crevices between the teeth), spongy, and tender. As regards *treatment*, it will be necessary to remove the source of irritation, so

far as is possible, to have the teeth scaled and made clean, and to use an antiseptic mouth-wash. Carious teeth should be filled or extracted. If the inflammation become chronic and, as a result, the gums are permanently thickened, they may be washed over with a solution of cocain and then treated by multiple puncture with a fine thermo-cautery needle.

Tumors of the gums may be simple or malignant. From the fact of a tumor being "upon the gum" it is apt to be called *epulis*—a term devoid of pathologic precision. It may be impossible to say at first whether a tumor of the gum is innocent or malignant, and, as a general rule, it will be safest to remove it while it is yet small and to examine it under the microscope, rather than wait until by

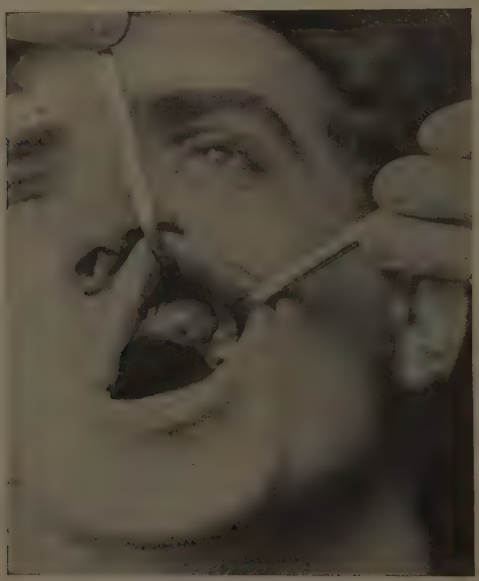

FIG. 366.—MALIGNANT EPULIS. (Binnie.)

its rapid growth or by some other sign its malignancy is placed beyond doubt.

"The operation itself consists in removing a tooth on each side of the growth so as to gain access to the bone. Then by a saw and bone forceps all of the alveolar process and the tumor are removed. Any less radical operation, even in apparently non-malignant cases, is apt to be followed by recurrence."

Figs. 364 and 365, from photographs kindly supplied by Col. R. D. Murray of the Indian Medical Service, show a malignant epulis (fibrosarcoma) of the lower jaw, and the excellent results obtained by operation and the subsequent adjustment of artificial teeth.

One of the commonest forms of growth from the gum is a capillary or venous *nævus*. It shoud be promptly dealt with by the thermo-cautery or by electrolysis. A simple form of epulis is the mass of granu-

lation tissue springing from a gum which is irritated by a carious fang. It may be treated by removal of the tooth and by the use of a small sharp spoon.

Congenital hypertrophy of the gum may be associated with intellectual deficiency, but though called "congenital," it may not have occurred until the first teeth were being cut.

Myeloid sarcoma is a common form of epulis and is more likely to occur upon the lower jaw. Though classified among the sarcomata, it does not possess the characters of those growths—it is encapsuled and it does not implicate the lymphatic glands. A myeloid sarcoma forms a rounded outgrowth from the gum or, rather, from the alveolus, and it is of that dusky reddish-brown tint known as "maroon." When it springs from the interior of the bone it causes absorption of the osseous tissue, and the periosteum laying down a thin layer of new bone over its surface, that peculiar and characteristic feeling known as "egg-shell crackling" may be detected. In former times extensive operations were performed upon the jaw for the removal of a myeloid sarcoma, but now that its comparatively benign nature is recognized, the surgeon contents himself with removing the teeth which are loosened by the growth and then thoroughly scraping away the morbid tissue by means of a strong sharp spoon.

Sarcoma of the most malignant form may spring from the gum, from the periosteum of the jaw, or from the alveolus. That variety which grows from the maxilla may increase rapidly in size and, having bone deposited in its base, it is well called *ossifying sarcoma*.

Epithelioma of the gum is rarely a primary condition; but malignant ulceration of the lip, cheek, or tongue is apt to invade the gum.

THE JAWS.

Deformities of the jaws have a prejudicial influence upon the development of the teeth; if the jaws are small the teeth are so crowded that some of them have to be sacrificed. In early life the jaws are quite plastic; this is well shown by the way in which the mandible is sometimes everted by the contraction of a scar left after an extensive burn. The dental surgeon makes use of this plasticity in widening a narrow arch. By the constant sucking of its thumb the young child is apt to press back the soft alveolar process of the lower jaw and to thrust forward the other, so that when the upper incisor teeth are cut they are spread forward. Prominence of the lower jaw causes the individual to be "under hung." Other deformities may render the jaw V shaped or saddle shaped, but if the surgeon can get to work upon the case early he can greatly improve it.

Abscess or "Gum-boil."—(See Vol. I., p. 260.)

Periostitis and **osteomyelitis** are the direct result of infection by germs spreading, in all probability, from a carious tooth. Osteomyelitis is the more serious condition, as the inflammatory effusion into the unyielding tissue not only causes intense pain, but is likely to entail

thrombosis of the vessels and necrosis. The deep-seated inflammation is associated with much swelling about the jaw and cheek. The breath is extremely foul and the patient, unable to eat or sleep, is in great distress. If the disease is allowed to progress, suppuration takes place, the abscess bursting into the mouth or on to the surface of the face. As soon as the pus escapes, pain subsides, and in all probability a sinus remains running down to the diseased bone; periosteal thickening takes place and, if necrosis has occurred, the probe will sooner or later find bare bone.

Treatment.—The presence of a painful swelling about the jaw should at once cause the surgeon to make a close inspection of the teeth, and, even in these days of praiseworthy conservatism in connection with dental troubles, there should be no hesitation about extracting the offending tooth. The fact that the patient is unable to open his mouth is no longer regarded as an excuse for delay; if the forceps cannot be introduced into the mouth the tooth must be removed by an elevator. After the extraction everything may at once quietly settle down. But if the case be allowed to drift on, the destruction may be extreme; especially is this likely to happen in children.

Necrosis.—Although the usual cause of the acute inflammation which leads to maxillary necrosis is the presence of septic microörganisms, still it is not the only one. The inflammation may be set up by the local action of the fumes of phosphorus, as used constantly to happen when less attention was paid to the condition of the teeth of match-makers, and when the employment of amorphous phosphorus had not yet been adopted. Necrosis of the lower jaw, far more frequently than of the upper, results from phosphorus. Another cause of the devastating inflammation was the excessive administration of mercury in the treatment of syphilis, especially in the case of those with bad teeth.

Injury, periostitis, a carious tooth, and occasionally one of the infectious fevers, such as typhoid or scarlet fever, may also be the cause of necrosis. There is intense pain, the teeth loosen and fall out, the breath becomes very foul, and pus discharges into the mouth through sinuses, and not seldom also externally through the skin, resulting in much disfigurement. During the process of the separation of the necrosed piece of bone from the living, a large amount of new osseous tissue is formed from the periosteum, which, in the case of the lower jaw, and especially in young persons, may eventually mold itself into a useful substitute for the portion of bone which was lost.

No attempt to remove the dead bone should be made until it is entirely loose. This can be determined by a probe. The sequestrum should always be removed through the mouth, if possible, so as to avoid further disfigurement (see Necrosis, Vol. II., p. 26).

Actinomycosis (the "lumpy jaw" of cattle).—(See Vol. I., p. 520.)

Hyperostosis is an overgrowth of bone; it may be of cancellous, spongy tissue, which is easily removable by a gouge, or it may be as dense as ivory. The latter kind of tumor is smooth, flat, and rounded. The growths are painless and innocent. If the surgeon determines to

try to remove an ivory one from the lower jaw he should be provided with strong saws and with a powerful electric motor for working them.

Dental exostoses are rounded outgrowths from the cement of the fang. They were formerly described as being the result of chronic inflammation in the peridental membrane; a more probable explanation is that they are radicular odontomes. They consist of dentin and cementum in varying proportions. Sometimes they spread from fang to fang, locking the teeth together.

Cysts.—A cyst may quietly arise near a carious spot at the end of the root of a tooth and, increasing in size, may give rise to a painless expansion of the alveolus until only an eggshell layer of bone encloses it. When, in the course of treatment, the cyst is laid open and the dead tooth removed, the wall of the cyst should be entirely cut away and the space plugged with gauze.

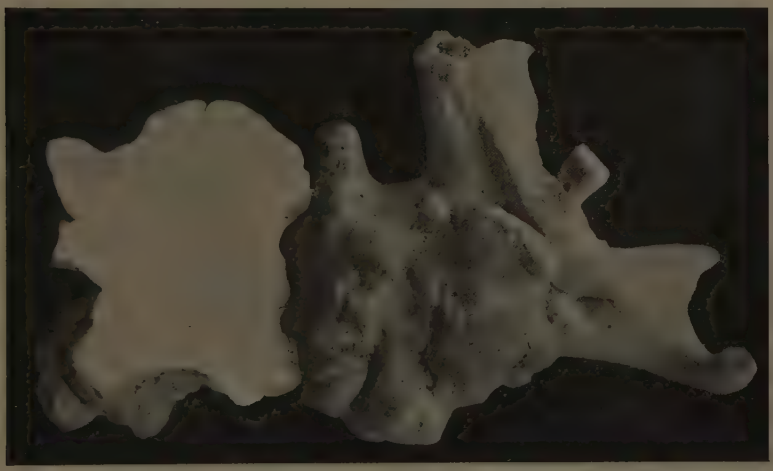

FIG. 367.—TUMOR OF LOWER JAW.

Taken from a specimen of exostosis of the lower jaw in the Hunterian Collection (No. 2212). Section has been made of the tumor to show its interior, which is uniform in texture and as hard and heavy as ivory. The tumor bulged on each side of the jaw and measured nearly 3 inches [illegible].

Multilocular cysts are more common in the lower jaw. They begin in the interior of the bone and, increasing in size, bulge in rounded masses through the surface layer of bone and push forward the mucous membrane or skin. Their treatment demands the free use of the gouge and sharp spoon. These are probably the result of erratic growth from the enamel organ as shown in Fig. 368. Most of these cystic cases, formerly taken for malignant disease, are odontomata. Cystic tumors of the jaw are now dealt with on much more conservative lines than was the case when they were regarded as more or less malignant.

Tumors of the Jaws.—A central **fibrous tumor** of the upper jaw may slowly bulge on to the cheek or into the buccal, nasal, or orbital cavity, attaining, if left, an enormous size. It is likely to be enclosed by a thin shell of compact bone, at any rate toward its base,

but as it approaches the alveolar border it is covered only by mucous membrane. Eventually it forces the anterior and posterior surfaces of the alveolus apart and the teeth fall out. As these large fibromata are more closely studied they will mostly be found to be odontomata growing from the tooth follicle. They are certainly innocent growths, and they can be enucleated without danger and without risk of recurrence. Fibrous outgrowths occasionally take place from the periosteum. They should be removed as soon as it is found that the administration of iodid of potassium has no influence upon them.

Sometimes a fibrous tumor of the jaw is due to the quiet irritation of a carious fang around which a large amount of developing granulation tissue has formed. In accomplishing its removal the surgeon may, perhaps, discover the unsuspected cause of the trouble.

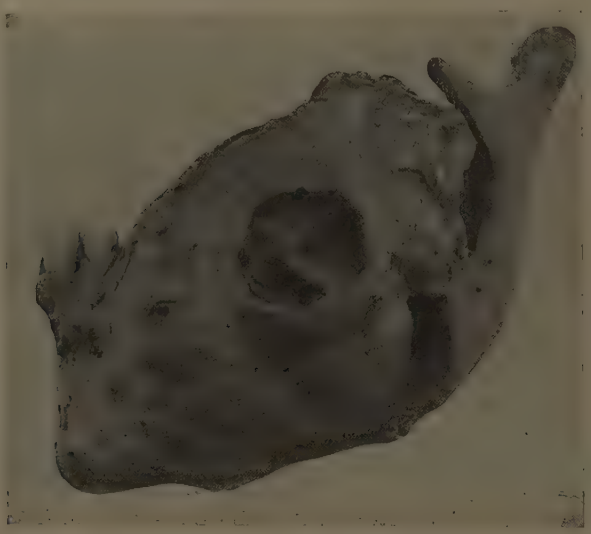

FIG. 368.—MULTILOCULAR CYSTIC EPITHELIAL TUMOR OF LOWER JAW.

Taken from a specimen presented to the Museum of the Royal College of Surgeons of England by the illustrious Robert Liston (No. 2198). In former times such tumors were suspected of malignancy. But now, chiefly owing to the work of Bryk and Eve, they are recognized as being the result of an erratic growth from the enamel organ and will be found described in Vol. I., p. 784.

Cartilaginous tumors of the jaws are rare. If they arise from the interior of the bone (*enchondroma*) their exact nature may not be recognized until they have been enucleated. If they spring from the periosteum (*perichondroma*) it may be made out by puncture that, though hard, they are not bony, and that, though somewhat elastic, they do not contain fluid. They can be easily removed by a gouge.

Odontomata are tumors of dental tissues arising in connection with the development of the teeth. Their anatomic and histologic characters are discussed in Vol. I., p. 784.

Follicular odontomes are generally associated with the teeth of the lower jaw and they may attain a large size. They grow very slowly—

a point which distinguishes them from malignant tumors. They do not suppurate—which distinguishes them from inflammatory growths. The mucous membrane and bone which close them in may be stretched very thin.

They must be treated by the removal of the wall, and when the interior of the base has been thoroughly scraped, the place must be plugged with gauze. During the operation the imperfectly developed tooth should be sought out for removal.

Epithelial odontomes are also likely to occur upon the lower jaw. They are outgrowths from the enamel organ and they appear as hard protrusions beneath the mucous membrane in a manner suggestive of myeloid sarcoma (Vol. I., p. 784). Attacked with scalpel and sharp spoon, they break up into epithelial débris and, being encapsuled, they come clean away. The space is then firmly packed with gauze.

Osteomata.—Multiple osteomata of the alveolar process may be removed by the gouge.

Leontiasis ossea is a diffuse hypertrophy of the bones of the face, and derives its name from the broad, leonine appearance which the condition imparts. The disease begins in the superior maxilla, and the first sign of its appearance is likely to be a hard, painless swelling near the base of the ascending process on either side of the nose. The lower jaw and the other bones of the face are slowly involved; the wall of the skull is also thickened. It is a rare disease and begins before middle age. It is not a syphilitic manifestation. As the disease is coming on it may give rise to pain by pressing upon the cranial nerves, but in due course the maxillæ are converted into shapeless masses of solid bone, the nerves of sense being destroyed in the process. The disease does not lend itself to effectual operative treatment, but by the use of the electric saw, or of mallet and chisel, a certain amount of the surface growth may be removed to the advantage of the personal appearance.

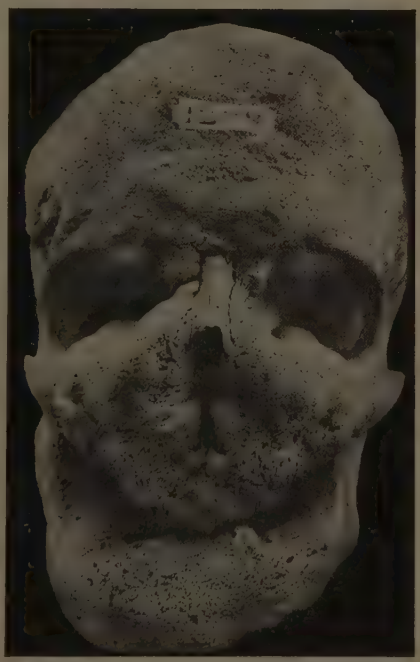

Fig. 369.—Leontiasis Ossea.

The illustration is taken from a specimen of leontiasis ossea in the Hunterian Collection (No. 1238), all the bones of the face being thickened. The nasal fossæ and orbits are nearly closed up. The hinder part of the vomer is ½ inch thick. The tissue of the growth is hard, but finely porous.

Empyema of the Antrum.—Suppuration in the antrum of Highmore is secondary to septic disease of a tooth, of the maxilla itself, or of the

nasal fossa. It begins with pain and throbbing, and soon a swelling appears in and beneath the cheek. By pressure pus may, perhaps, be made to ooze through the alveolus, or it may discharge spontaneously into the nasal fossa and escape by the nostril, especially when the head is lowered and inclined toward the other side. If the pus does not find a way of escape the floor of the orbit may be raised, and the thinned anterior wall of the antrum may be pushed forward.

Treatment.—The suspected tooth must be extracted and the socket drilled through into the antrum, which must then be curetted and drained. If there is no suspicious tooth the cheek should be raised and an opening made into the antrum through the canine fossa, large enough to admit the end of the exploring finger. The cavity should then be scraped and stuffed with gauze, and unless the operation is carried out in a thorough manner it may have to be repeated.

Sarcoma; Carcinoma.—**Sarcoma** is very apt to attack the jaws; it may start in the interior, from the cells of fetal marrow (central or myeloid) or from the surface of the bone and the periosteum (peripheral). In the former case the growth lacks the characteristics of malignant disease, for it is encapsuled; it does not implicate the lymphatic glands and, when effectually removed, does not recur. In its growth it causes a gradual absorption of the bone and eventually reaches the periosteum, which slowly yields under its pressure, but which, nevertheless, continues to form new bone. Thus, a thin and brittle layer of bone may incrust the central sarcoma, giving rise to the characteristic "eggshell crackling."

This variety of tumor is of more frequent occurrence in childhood and early life, and grows rapidly, the mucous membrane being sometimes ulcerated over it. It is of a brownish-purple color. It is not unlikely that many cases which have been called central sarcomata of the jaws were really epithelial or fibrous odontomata. A central sarcoma protruding through the alveolar process is one form of epulis.

Treatment.—A central sarcoma may be effectually dealt with by the gouge, the surrounding bone being scraped until healthy tissue is left. If this is done thoroughly there will be no return of the growth, for it is not *malignant* in the usual sense. In certain advanced cases it may be advisable, however, to use a fine saw or cutting forceps in the removal of the affected tissue, but in the case of the operation being upon the lower jaw, the surgeon should do his best to leave the basilar process intact.

Peripheral sarcoma starts from the connective tissue of the surface of the bone or from the periosteum. It knows no limits and in its growth it may fill the antrum, involve the cheek, mouth, tonsil, nose, or orbit, or, spreading from the lower jaw, may implicate the skin, the mouth, or the tissues of the neck. Its great clinical feature is rapidity of growth. The skin eventually gives way and a fungating mass protrudes. Inasmuch as the tumor probably takes origin in the deep layer of the periosteum, extending thence into the bone, its depths are likely to be impregnated with the bone-salts, and the tumor is then

spoken of as an *osteosarcoma* or an *ossifying sarcoma*. Obviously it cannot be incrusted with bone or give rise to the eggshell crackling, as mentioned in connection with the myeloid sarcoma.

Sarcoma filling the antrum soon presses upon the nasal duct and causes the tears to flow over the cheek; and blood-stained mucus oozing from its surface finds its way into the pharynx or out by the nostril. The tumor may cause severe bleeding from the nose. If the growth starts from the back of the superior maxilla it may bulge into the pterygoid region and into the back of the orbit, pushing forward the maxilla as well as the eyeball. Pressure upon the divisions of the fifth nerve may give rise to pain in the regions in which the sensory filaments of that nerve are ultimately distributed. Thorough exploration with the finger gives information as to the extent and fixity of the growth.

FIG. 370.—OSSIFYING SARCOMA SPRINGING FROM THE UPPER JAW.

Hunterian Collection (No. 1712). As is the nature of this form of disease, it is seen to be spreading to and growing from the adjacent bones. The tumor, which was five years in progress, destroyed the right orbit and blotted out the bones which it had involved.

The cervical lymphatic glands are involved sooner or later; the appetite and vigor of the patient steadily grow less and the outlook becomes desperate. The most likely seat of secondary deposit is the lungs.

Early operative treatment gives the only chance, and it not seldom happens that even in most unpromising circumstances the operation can be brought to a satisfactory conclusion in spite of dangers and difficulties which had previously seemed almost unsurmountable. Still, a rapidly growing, soft, and ill-defined mass, which readily bleeds and has infected the lymphatic glands, would not invite an attempt at excision.

The patient having been duly prepared and brought under an anesthetic—but not too deeply—is placed in the head-downward position (p. 615). The incision may be made along the lower border of the orbit, down the side of the nose, around the ala to the septum, and thence through the middle of the upper lip (see Chapter on Operations on Bones and Joints). The large flap is raised and turned outward. The malar and nasal processes are then divided by saw and bone forceps and, lastly, the palatine process is cut through close to the septum by the bone forceps. The mass is then grasped by lion forceps and twisted out, the connections by nerves and soft parts being divided with scissors or thermocautery; the space which the mass occupied is then quickly stuffed with gauze to check the hemorrhage which is always free. No vessels, as a rule, require the ligature. In a few minutes the hemorrhage will cease, when the gauze is taken out and all diseased tissue is carefully and widely removed. It is always best also with rongeur forceps to gnaw away the anterior wall of the infundibulum up to the frontal sinus, since if the case is at all advanced there will then be found a tongue of sarcomatous tissue extending up toward and often even filling the frontal sinus. To leave this unsuspected diseased tissue behind is to invite recurrence. When all diseased tissue has been removed the large cavity is packed with gauze for two or three days. After the operation the mouth and nostrils should be frequently sprayed with suitable antiseptics for about a week.

It is often impossible for the surgeon to be certain if a tumor starting from the superior maxilla is malignant or not, though if it is growing quickly and glands are enlarged there cannot be much room for doubt. His business, however, is if possible to clear it away at the earliest moment, and if this can be done only by an extensive operation, still it must be done. The exact nature of the growth can afterward be determined in the laboratory.

In a few months after complete removal of the upper jaw it is remarkable how little deformity is left. The eyeball drops a little and the cheek falls in, and on examining through the mouth it is seen that the surrounding tissues have come together and obliterated what was, at the time of the operation, a vast yawning cavity. An artificial denture aids this cosmetic effect and also very largely restores the voice.

Dr. Dawbarn[7] affirms that as sarcoma is spread by the blood-vessels its growth may be checked by "starvation," that is, by plugging the arteries passing to it by injecting them with white wax and vaselin. Before injecting the vessels, he says that the surgeon must see well to it that the artery is the external and not the internal carotid, as instant death would follow injecting the circle of Willis.

In the case of malignant disease of the jaws, together with this plugging he practises excision of the external carotid. Veins as well as arteries are to be sacrificed. At an interval of three weeks he ties both external carotids, beginning with that on the *sound* side. To

obliterate only one external carotid is, he says, "simply a waste of time." This starvation method has in certain otherwise hopeless cases brought about a definite shrinkage of the growth, and not only has pain been lessened by it, but it has given the patient one more chance.

Epithelioma of the mouth may come on so quietly that the patient may give little heed to it until it has implicated the maxilla and, perhaps, extended into the pharynx. It may have begun on the gum, cheek, or tongue, or in the mucous membrane lining the antrum or pharynx. The cervical glands will be implicated and when the surgeon is at last consulted the condition is such that if he considered only his peace of mind he would decline to interfere. But if operation is refused the outlook is without hope and the patient loses the comfort which is always associated with the fact that a determined attempt has been made to free him of his disease. In all cases, therefore, where there is a fair chance of the surgeon being able to get the entire mass away he should give the patient the benefit of that chance, placing before him the exact position of affairs and letting him decide for himself. It is quite likely that the patient will then turn to the surgeon, as a friend, and say, "If you were in my position, knowing what you do, would you yourself undergo the operation?" And the answer being based upon the surgical golden rule of treating one's patients exactly as, in similar circumstances, one would wish to be treated, it is likely to be finally accepted, whichever way it goes.

A week or ten days before attacking the malignant growth the surgeon clears away all the enlarged lymphatic glands from the neck, laying bare the carotid vessels and, if need be, sacrificing the internal jugular vein in the determination to remove all the tissue which has been secondarily invaded. Both sides of the neck may have to be similarly treated. Then, when the wounds have healed, he undertakes the removal of the primary growth.

For the second part of the operation, a stimulating enema having been administered just before the man is placed upon the table, and due provision having been made against hemorrhage and shock, a laryngotomy is performed and the pharynx is plugged with gauze. The incisions must be free, so that the surgeon has plenty of room, for it is impracticable to attempt a large operation through a small wound. The risks of the operation—and they are very serious—are from shock, hemorrhage, and septic pneumonia.

Dr. Cobb [8] is of opinion that the average duration of life is longer in cases operated upon than in the others and, moreover, that operation is followed by mental and physical comfort, a point to which the writer has already referred.

Wounds and Injuries of the Jaws.—Fractures are dealt with in Vol. II., p. 147, but it may here be noted that they are of special interest in that the periosteum is, in places, so closely blended with the mucous membrane that a fracture is very apt to be compound. The microörganisms of the mouth having thus found access to the damaged

bone, septic ostitis occurs, which may lead to suppuration, necrosis, or pyemia.

As the result of great violence the upper jaw may be broken, and, the wall of the antrum being driven in, emphysema may occur. The exact nature of such fractures may generally be made out by exploration with the finger. By the use of a strong elevator the displaced pieces of bone may be readjusted, the patient being afterward fed upon fluids until consolidation has taken place.

The commonest cause of **neuralgia of the fifth nerve,** or tic douloureux, is the irritation of one of its filaments by a carious tooth (see Vol. II., p. 696). A similar clinical phenomenon is pain referred to the branches of the obturator nerve at the knee, when other filaments of that nerve are being irritated in hip-joint disease (Vol. II., p. 319). It is at present impossible to explain these referred pains.

Facial neuralgia is more common among women than men. In some cases it is dependent upon pregnancy and in others it seems to be due to a general disordered state of the system. In every case the teeth should be examined, one by one, and any suspicious place attended to. Every nook and cranny beneath the overhanging gums should be searched with a fine probe. "The crown of a sound tooth is often tightly wedged against a carious neighbor" (Sewill)—such a place must be duly inspected. The lower wisdom tooth should be particularly looked to. Syringing a doubtful tooth with a fine stream of cold water (especially if the tooth has a metal filling) may discover a tender focus and may lead to the temporary removal of the filling. In no case should the teeth be removed unless they are diseased. The treatment of neuralgia by injections of alcohol has met with considerable success.

THE TEMPOROMAXILLARY ARTICULATION.

In carnivora the temporomaxillary articulation is a hinge, but in omnivorous man it is a gliding joint. Between the shallow temporal socket and the mandibular condyle is a fibrocartilage, which receives some of the insertion of the external pterygoid muscle and therefore follows the movements of the condyle. The external lateral ligament, short and strong, is connected with this cartilage. The internal lateral ligament, though longer, is less important. There is a separate synovial membrane on each surface of the cartilage and the joint is enclosed in a capsule.

The nerves of the joint are derived from the third division of the fifth, which also supplies filaments to the teeth of the lower jaw. Consequently, when one of the dental filaments is in trouble, as in the case of the painful eruption of a tooth or of inflammation about a pulp-cavity or a fang, pain is apt to be referred to the articulation and, perhaps, spasmodic closure of the jaw may occur. In such cases careful examination of the teeth should be made with a view of removing

nerve tension. And for this purpose it may be advisable temporarily to remove a filling.

Arthritis may be due to gout, rheumatism, tuberculosis, scarlet fever, or to gonorrheal or some other form of blood poisoning. It may be secondary to acute otitis or to inflammation of the lower jaw itself, and may be treated, according to its degree, by anodyne frictions, fomentations, leeches, or, in rare pyemic cases, by incision.

Noisy mastication may be due to disturbance of the innervation of the joint by the peripheral irritation of a dental filament. The writer has known a troublesome case of this sort suddenly recover on the removal of inflammatory pressure beneath a filling. When it is due to chronic degenerative changes in the joint, as in osteo-arthritis, treatment is very unpromising. This affection is apt to involve each temporomaxillary joint as well as other articulations.

Permanent closure (ankylosis) of the jaws may be dealt with by resecting the condyle or by taking a wedge-shaped piece out of the ramus, the apex of the wedge being directed forward. As soon as the skin wound is soundly healed the jaw should be regularly moved, so that a false joint may be formed.

When the jaw is fixed by the contraction of scar tissue division of the bands may give improvement, but if the tissue is very thick osteotomy, as just described, will probably be needed. Division of the maxilla in front of the cicatricial bands, and the establishment there of a false joint, may prove effectual treatment.

Dislocation of the Lower Jaw.—(See Vol. II., page 389.)

Injuries.—Dislocation of the jaw forward takes place when the mouth is wide open, and either a blow upon the point of the chin or the energetic contraction of the pterygoid muscles brings the condyle in front of the eminentia articularis. As a rule, the fibrocartilage follows the condyle. The dislocation may be symmetric or unilateral.

Symptoms.—The mouth remains wide open, so that the saliva flows out and feeding and talking are difficult.

Treatment.—When the condyle is unhitched from the front of the articular eminence muscular contraction suddenly pulls it into place and the teeth come together with a snap. The surgeon, therefore, who is trying to reduce the dislocation with his thumbs should be careful to protect them from the injury of a sudden bite by wrapping them in the corners of a towel.

Fracture of the neck of the condyle may be caused by severe injury. Dr. Roe, of Philadelphia,[10] has collected 41 cases of this nature. If the injury happened in early life and the jaws became ankylosed (a very likely result), arrest of growth of the mandible takes place, the chin being small and retracted.

On mobility being once more imparted to the jaw by resection of the condyle or condyles, there is a risk of the air-way being blocked by the sinking of the base of the tongue to the back of the pharynx. This may be so serious as to demand a laryngotomy.

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CHAPTER XLIV.

SURGERY OF THE TONGUE.

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CONGENITAL ABSENCE OF THE TONGUE.

By this term is meant absence of the anterior, or projecting portion of the tongue; the base is never congenitally absent. It is claimed by some observers that congenital absence of the projecting portion of the tongue does occur; but if it does, it is infinitely rare. It may be confused with destruction of the tongue in infancy.

SPLIT OR BIFID TONGUE.

Occasionally a child is observed in whom the anterior portion of the tongue is cleft in the median line longitudinally. This condition is known as split or bifid tongue, and this developmental defect is analogous to a condition of the tongue normal in some of the lower animals. A bifid tongue does not seem to interfere with function, but if the deformity is regarded as objectionable, it may readily be corrected by making the surface of the gap raw and uniting the edges with sutures.

TONGUE-TIE.

In this congenital condition the tip of the tongue is closely anchored to the floor of the mouth by an excessively short frenum and by short mucous plicæ on the sides of the frenum. The vast majority of cases are slight—due, as Butlin[1] insists, entirely to tardy development; and in them development is completed and the condition amended as the child grows older. Established cases of severe tongue-tie are very rare. A really marked tongue-tie, in which the tip of the tongue is held firmly to the floor of the mouth, is called *congenital ankyloglossia.*

Mothers often insist that a child has tongue-tie when nothing of the sort exists, and they frequently demand that unnecessary operations shall be done for a trivial tongue-tie, which will pass away as the child grows older. Many needless operations are performed for this condition. If tongue-tie really exists, it is readily detected by lifting the tongue with the fingers from the floor of the mouth. In true tongue-tie the tongue cannot be protruded and sucking becomes difficult.

If the surgeon decides that an operation is necessary he should divide the frenum. He raises up the tip of the tongue with the fingers and nicks the tense tissue a little, close to the jaw, by means of a pair

of scissors. This cut goes completely through the mucous membrane, but must not involve the muscles beneath. The old advice, which was to tear the wound wide open with the finger-nail, should not be followed. Various accidents have followed careless or improper operations for tongue-tie. Fatal hemorrhage has occurred; cases of asphyxia from swallowing the tongue after division of the frenum have been recorded; and in some cases, after a tearing operation, an ulcer forms, which, by cicatrization, anchors the tongue more firmly than it was held before.

SWALLOWING OF THE TONGUE.

When the tongue is excessively mobile it may be swallowed, the organ turning over upon itself and the tip of it entering into the pharynx, or actually entering the esophagus. Suffocation may be induced by swallowing the tongue. Extreme mobility may be congenital, due to excessive length of frenum. It may arise after free division of the frenum for tongue-tie, and may occur after an operation involving the removal of the portion of the lower jaw to which the genioglossus muscle is attached. Tongue-swallowing is more common in idiots than in the mentally sound. A slighter degree of the same condition, in which the tongue falls back and obstructs the epiglottis, may occur during anesthesia. It may also occur in weak children, just as it does in anesthesia.

WOUNDS OF THE TONGUE.

Wounds of the tongue are by no means uncommon. An incised wound may be inflicted while a person is using a table-knife as a substitute for a fork. A child occasionally wounds itself by drawing a sharp-edged blade of grass through its mouth. The majority of wounds of the tongue are lacerated and are inflicted by the teeth or by bits of bone from the food. Another way in which a lacerated wound may be inflicted is by tearing with fragments of a broken jaw-bone, or with a bit of the broken stem of a tobacco-pipe. Punctured wounds are occasionally inflicted, and gun-shots wounds may occur.

Most lacerated wounds are trivial and transverse, and the common cause is biting the tongue while chewing food. In children, particularly, a very severe wound may be inflicted by falling and striking the chin while the mouth is open and the tongue between the teeth. A blow upon the chin with the fist may produce the same result. Such an accident may cause serious laceration, or a piece of the tongue may be bitten off. The tongue may be bitten in eclampsia, in uremia, and particularly in epileptic fits. In an epileptic fit the tongue is protruded and bitten on account of clonic spasms of the tongue and of the muscles of the jaw. In most cases there is only trivial laceration of the edges or tip, but sometimes there are severe lacerations, and occasionally a piece of the tip or of the edge is bitten off. The tongue may also be severely lacerated in tetanus.

Punctured wounds are inflicted by fish-bones, bits of bone in food, needles, etc. A foreign body may lodge in the tongue. Among bodies

that may lodge are bits of teeth or an entire tooth, fish-bones, bits of bone from food, bone-fragments from a fractured jaw, needles, tooth-brush bristles, and bits of a tobacco-pipe stem.

A wound of the tongue usually causes severe hemorrhage. If the wound is trivial, the hemorrhage soon ceases. If it is severe, the bleeding is violent and continued, and may prove dangerous or actually fatal. Secondary hemorrhage may occur if the wound becomes infected. Even when open bleeding ceases extravasation may continue in the tissues of the tongue, producing swelling which continues to increase, perhaps for two or three days.

The tongue is very resistant to bacterial action, probably because of the rich blood-supply, and trivial wounds and wounds of ordinary severity heal rapidly by first intention, and by the time a few weeks or a month or so have passed it is usually impossible to discover a scar.

A **foreign body** in the tongue may be seen and removed by the surgeon. It may, however, be missed and it may not even be suspected to be present. The surgeon should think of the possibility of such an occurrence if a wound, especially a punctured wound, fails to heal, if it bleeds from time to time, if an area of induration develops, and if an abscess or a sinus forms.

Any wound of the tongue may suppurate, and such wounds occasionally slough and are sometimes followed by glossitis or abscess. Wounds of the tongue are occasionally fatal. Death may be due to primary hemorrhage, to secondary hemorrhage, or to suppuration resulting from glossitis, abscess, extravasation into the tissues of the tongue, the passage of quantities of blood into the lungs, or edema of the glottis. In an individual with hemophilia the wound of the tongue may, of course, produce fatal hemorrhage. Such cases have been recorded.

Treatment.—A wound in the anterior portion of the tongue is easily seen and readily reached, and the bleeding can be arrested by the sutures that are used to approximate the edges of the wound. The best material to employ for sutures is black silk, as it is easily seen when one wishes to remove it. If a wound is situated in the back part of the tongue the problem is much more difficult. The bleeding can be temporarily controlled by pressure with the finger. As Heath has shown, this is best accomplished by pushing the forefinger back to the epiglottis, hooking forward the hyoid bone, and thus putting the lingual arteries on the stretch. Then an anesthetic may be administered. An anesthetic must always be given in the case of a child, and should usually be given in that of an adult, unless the wound is trivial in character, when cocain may be used to deaden sensibility. When the patient is anesthetized and has been placed in a good light, a stout piece of silk is carried through each side of the tip of the tongue and a loop is made. With this loop the organ is drawn well out of the mouth. The surgeon wipes out clots from the wound, and if he is able to observe a visible bleeding artery he catches it and ties it with catgut. If the bleeding

is arterial, but the vessel is not visible, the wound must be enlarged, in order that the vessel may be found and tied. In very rare cases of arterial hemorrhage it has been found necessary to tie the lingual in the neck, and in some cases the external carotid has been tied. It must be very seldom that there is any real need of such action for the arrest of primary hemorrhage. Venous and capillary bleeding may be arrested by the tying of the sutures that approximate the wound edges

In every wound of the tongue in which there is any possibility of a foreign body being embedded the surgeon must seek for such a body and remove it when found. After arresting hemorrhage, removing any foreign body, wiping away the clots, and washing the mouth and the wound with salt solution, the edges of the wound are approximated by sutures of black silk. All the sutures should be passed before a single one is tied. They are tied rather loosely, for the subsequent swelling will make them tight. One end of the wound is left a little open for drainage.

If a piece of tongue has been completely bitten off, the edges of the stump, after hemorrhage has been arrested, should be sutured, either with black silk or with reasonably strong catgut. When the tongue is nearly severed it should be sutured in place, in the hope that there will be enough blood-supply to permit of union. If a fish-hook is caught in the tongue it should be pushed until the barbed point emerges, and this point should be bitten off with bone-forceps, when the implement can be withdrawn. A crochet needle embedded in the tongue must be subjected to the same management.

In some cases of wounds of the tongue in which the hemorrhage is excessively violent it is necessary to do an immediate tracheotomy. This plan of treatment is strongly recommended by W. Kümmel.[2] When this plan is followed a tampon cannula is introduced into the wound, hemorrhage from the wound in the tongue is arrested, and the wound is sutured. Then the tampon cannula is removed and an ordinary tracheotomy tube is inserted and is kept in place for a time. A hematoma of the tongue requires incision and drainage, the drainage being effected by inserting a piece of iodoform gauze, which should be stitched in place for safety.

After the infliction of a wound upon the tongue no solid food should be given the patient for five or six days, and during this time the mouth should be rinsed out at frequent intervals with salt solution containing a little peroxid of hydrogen (4 : 1). Every time food is given the mouth should be rinsed with this mixture. The surgeon must be carefully on the lookout for infection, and if the stitches begin to cut they should immediately be removed. Great swelling of the tongue may require incisions. Edema of the glottis will demand tracheotomy. If secondary hemorrhage occurs the surgeon should endeavor to tie the artery in the wound, but he will probably fail to accomplish this, owing to the friability of the tissues. He will then be forced to tie the lingual or the external carotid.

Gun-shot Wounds of the Tongue.—A pistol bullet may lodge in the tongue and any bullet may wound that organ in its passage. Secondary hemorrhage or abscess is peculiarly liable to follow a gun-shot injury. In some rare cases the bullet becomes encysted. The bullet may carry in with it some other foreign body, such as a tooth or a bone-fragment, and this may become encysted. In a gunshot wound of the tongue preliminary tracheotomy should be performed, hemorrhage should be arrested, and the wound should be partly closed with sutures.

BURNS AND SCALDS OF THE TONGUE.

Trivial burns from hot food are common. A smoker often inflicts a slight burn by introducing the wrong end of a cigar or a cigarette into his mouth. Such a burn is painful for a time, the pain being aggravated on taking food. It presents a reddened area, which may be either smooth or excoriated. It gets well within a very few days, and should be treated with an astringent wash or a mouth wash containing chlorate of potassium.

A burned area may become ulcerated. In fact, it is liable to do so in smokers, because of continued irritation with tobacco. If such an ulcer forms it should be touched with nitrate of silver.

The tongue may be scalded with hot fluid, and may be dreadfully burned with boiling fluid. In such a case, the mouth and pharynx in general suffer with the tongue. The latter sort of injury is occasionally found in children and in lunatics from attempting to drink from the spout of a tea-kettle; and it may also arise from the inhalation of hot steam. The swelling is rapid and enormous, and large blisters form over the organ. There is considerable danger to life from edema of the glottis or from inflammation of the air-passages, and it may happen that the air-passages are immediately involved, or that the esophagus has been badly scalded. The proper treatment in a severe case consists in performing tracheotomy and then making incisions in the tongue.

Of course the tongue may suffer from chemical burns, the entire mouth, and usually the esophagus being involved. Among the agents sometimes responsible are carbolic acid, corrosive sublimate, the mineral acids, and the caustic alkalies. There is nothing peculiar about such burns, and they are treated as directed above.

STINGS OF THE TONGUE.

Stings by bees and wasps are rare accidents. They produce great swelling, but usually get well quickly. The danger is edema of the glottis. When there is no evidence of edema of the glottis the best treatment consists in the local use of ice. If there is the slightest evidence of edema of the glottis tracheotomy should be performed.

ACUTE SUPERFICIAL GLOSSITIS.

Acute superficial glossitis may be circumscribed or diffuse. The circumscribed form results from some ordinary traumatism, such as

a burn, a scald, an abrasion, a scratch, an irritation with tobacco, etc. Such a condition is soon recovered from, and is treated by removing the cause and using an astringent mouth-wash.

Diffuse superficial glossitis is a condition that occurs in thrush, in general stomatitis, and sometimes in diphtheria. In very rare cases it results from infection from an animal suffering with foot-and-mouth disease. Superficial catarrhal inflammation occurs in fevers and gastro-intestinal disorders, and constitutes the coated tongue of these conditions. The lingual papillæ enlarge, epithelium desquamates and is heaped up, and bacteria gather. The strawberry-tongue of scarlet fever is due to enlargement of the fungiform papillæ. Certain diseases of the tongue resemble skin diseases; for instance, geographical tongue and herpetic hemiglossitis. Syphilis produces various inflammatory disorders, usually transitory in duration and exfoliating in character. A certain form of exfoliating inflammation is likely to occur during dentition. The treatment of diffuse superficial glossitis is conducted on general principles, and the causative disease may also require particular treatment.

ACUTE PARENCHYMATOUS GLOSSITIS.

This is a rare disease, most common in young adults, unusual in the aged, and very unusual in children. It is much more common in men than in women, and tends particularly to occur in the winter months.

It begins suddenly with pain on chewing and with stiffness of the tongue, which greatly interferes with speech and mastication. In a few hours pain is felt, even when the tongue is quiet, the pain being in the tongue, in the maxillary region, in the neck, and also, perhaps, in the ear. Swelling begins at once and within twenty-four hours becomes enormous. The tongue is projected far out of the mouth, and is held there, rigid and immovable. The teeth—particularly the under teeth—cut into it. The pain is constant, usually severe, and aggravated by the slightest attempt at movement. The tongue is commonly almost covered with a heavy white coating, the portion not so covered being bluish in color, but frequently the organ is glazed and quite dry. There is profuse salivation, the fluid dripping freely from the mouth; the patient is almost or quite unable to speak, has great difficulty in swallowing, usually suffers with dyspnea, and is certain to do so if the posterior portion of the tongue is involved in the process. The submaxillary lymphatic glands are swollen, and the submaxillary salivary glands are usually enlarged. There is elevation of temperature, frequently to 102° or even more.

In three or four days, as a rule, the symptoms begin to abate. The swelling lessens, dyspnea ceases, swallowing becomes easier, and speech is again possible. Here and there upon the tongue a localized slough may take place and at the point of sloughing ulcers form. If improvement continues the condition is practically recovered from in a short time. Suppuration sometimes, but seldom, occurs, a deep abscess

resulting. In deep abscess it is very difficult to obtain fluctuation. Gangrene of the tongue is extremely rare, but may occasionally arise.

This form of inflammation of the tongue is frequently dangerous. It may kill a person in a few hours from edema of the glottis, or death may take place from exhaustion, from septic pneumonia, from gangrene of the tongue, or from widespread suppurative glossitis. At the termination of the inflammation adhesions may form and greatly limit the movements of the tongue, or the swelling may only partially abate, and the tongue remain thick and clumsy for many weeks or months, or perhaps even permanently.

Among the **causes** that predispose to acute parenchymatous glossitis we should mention specific febrile maladies, salivation by the administration of mercury, and the effect of cold and dampness. Butlin[3] points out that this condition occurs especially in the winter months when colds are common, and that it not unusually begins with the muscular pains and general depression which commonly constitute the symptoms of the so-called cold. Certain it is that the disease tends to occur particularly in those of debilitated constitution. Another predisposing cause that is occasionally noted is an infected wound of the tongue.

The real cause, however, must be sought in bacteria. We know that the mouth contains quantities of pathogenic organisms. The tongue normally has a strong resisting power to bacteria, but when its vital resistance is lessened by injury or by some of the other causes mentioned, organisms previously inert become active for harm. Streptococci produce the most virulent and dangerous form of glossitis; staphylococci cause a less severe form, which may occasionally be circumscribed into an acute abscess.

Treatment.—In general, the treatment of acute parenchymatous glossitis consists in making an incision on the dorsum of the tongue on each side of the median line. Such an incision relieves the tension, affords drainage, and is followed by the rapid abatement of the swelling. Butlin[4] advises that each incision should be about two-thirds of an inch from the raphe, and should penetrate to the depth of one-third of an inch, and that it should be made with an extremely sharp, curved bistoury. Such an incision will not be productive of dangerous or even serious hemorrhage. In violent cases of glossitis, especially those due to streptococci, there is frequently a rapid involvement of the tissues of the neck. It then constitutes Ludwig's angina, which is described on p. 292 and Vol. I., p. 346. Streptococcic glossitis requires free incisions into the tongue and probably into the neck, usually tracheotomy, and always the administration of antistreptococcic serum. Glossitis due to staphylococci is the form that particularly follows an injury of the tongue. It should be treated by early incision, which tends to prevent abscess formation, and if an abscess forms, the pus must, of course, be evacuated.

Mercurial glossitis is by no means so common as it used to be, because physicians at the present time administer mercury with care.

Butlin[5] points out that the tongue in mercurial glossitis is not swollen so greatly as in the other forms; that superficial sloughing tends to occur, and that the character of the enlargement is edematous rather than firm. The foulness of the breath and discharges in this form of glossitis are fearful. The gums are characteristically swollen and bleeding, there is dreadful salivation, the teeth are loose, and there is seldom much fever. In mercurial glossitis the administration of the drug must be at once suspended. Iodid of potash must not be given. The mouth should be washed out at frequent intervals with a solution of permanganate of potash or bichlorate of potash, and after a day or two with astringent washes. Hot baths should be given, stimulants should be administered, and tonics should be employed. It is seldom necessary to make incisions for mercurial glossitis and such cases are practically never fatal.

Gangrene of the tongue is, fortunately, a very rare condition, though it occasionally occurs. Cases are on record in which almost the entire tongue has sloughed away. If a gangrenous area forms in the tongue the dead parts should be cut away, the stump should be seared with pure carbolic acid and dusted at regular intervals with iodoform. Mouth washes of peroxid of hydrogen or permanganate of potash should be employed at frequent intervals. In such a case there is the gravest peril of septic pneumonia and considerable danger of edema of the glottis.

ACUTE HEMIGLOSSITIS.

One-half of the tongue, usually the left half, may be attacked by parenchymatous inflammation. The condition is extremely rare. The symptoms are similar to, but milder than those of general parenchymatous glossitis, and the condition usually remains limited to the side on which it begins. Occasionally, however, it spreads to the opposite side, but even when it does so the side secondarily involved never becomes so much swollen as the side primarily affected.

The treatment is similar to that used in general parenchymatous glossitis, but incisions are seldom required.

A curious form of hemiglossitis, in which herpetic vesicles appear on the tongue, sometimes arises in association with herpes of the face. It is unquestionably of nervous origin. The treatment consists in the use of mildly astringent mouth-washes and in the administration of sodium salicylate.

THRUSH.

This condition is considered on page 634.

ABSCESSES OF THE TONGUE.

Abscesses of the tongue may be acute or chronic.

Acute Abscess.—Acute abscess is not very common. The tongue has a high resisting power to bacterial infection, even when the surface epithelium is destroyed, and, as previously stated, wounds usually heal by primary union. Acute abscess may arise in the course of acute diffuse parenchymatous glossitis, although it seldom does. It may also

arise in an area of circumscribed inflammation. There are two forms of acute abscess, the superficial and the deep.

Superficial Acute Abscess.—A superficial abscess takes origin just beneath the mucous membrane, and is most commonly observed on the dorsum of the tongue toward the base; but, even when toward the base, it is almost invariably in front of the circumvallate papillæ. A superficial abscess may arise without an antecedent injury, the bacteria having entered directly into the mucous glands. It may follow a traumatism that has opened the way to bacteria by injuring or destroying the mucous membrane. The onset is gradual rather than rapid. The pain is felt at the seat of suppuration, and also perhaps in the ear, but is not violent. A swelling develops at some portion of the tongue and the entire organ may be more or less enlarged. The swollen area is tender and somewhat painful, becomes yellowish in spots, and after a time fluctuates. The general swelling of the tongue interferes with deglutition and articulation. Early spontaneous rupture never occurs.

The condition may be confused with a mucous cyst, but a cyst is of very slow development, is free from pain, is translucent, and is behind the circumvallate papillæ. A superficial abscess may also be confused with a gumma, but a gumma begins in the substance of the tongue, develops very slowly, is quite painless, and does not fluctuate.

Treatment.—A superficial abscess is treated by incision and by the use of antiseptic or astringent mouth washes.

Deep Acute Abscess.—This condition may arise during the progress of acute parenchymatous glossitis. It is sometimes found in true mercurial glossitis. It may follow the infliction of a punctured wound or the entrance of a foreign body. When an abscess forms the pus is so deeply placed that fluctuation is never an early symptom. Such an abscess may readily be mistaken for a gumma, unless it has been preceded by acute general glossitis.

Treatment.—Incision and mouth washes.

Chronic Abscess.—We use this term not as synonymous with tuberculous abscess, but rather to signify a slowly developing and low-grade pyogenic infection. In this condition acute symptoms are absent, owing to the high level of vital resistance to bacteria, or on account of the fact that the micro-organisms of suppuration are attenuated in strength. A chronic abscess of this sort may result from an injury, but in most cases is due to secondary pyogenic infection of a tuberculous focus or of a gummatous area.

The condition is a very unusual one. It is decidedly more common in adults than in children. It arises insidiously and develops very gradually. It presents no acute symptoms whatever and seldom becomes larger than a marble. It may develop beneath the mucous membrane, but is far more likely to arise deep in the tissues of the tongue. It is smooth and rounded in outline and is free from pain and tenderness. It is never translucent and very seldom fluctuates.

Owing to the situation and the slow development of such an abscess, and on account of the absence of inflammatory signs, it is impossible

to differentiate it from gumma, except by means of the therapeutic test. A superficial chronic abscess may be confused with a mucous cyst, but, as Butlin says in his valuable work on "Diseases of the Tongue": "Abscess is common on the dorsum of the tongue in front of the circumvallate papillæ, while mucous cysts are found behind the papillæ; cysts are usually more prominent than abscesses, and abscesses are never translucent."

Treatment.—When in doubt as to whether the condition is chronic abscess or gumma, give large and advancing doses of iodid of potassium as a therapeutic test. When convinced that an abscess exists incise it.

SUBACUTE AND CHRONIC SUPERFICIAL GLOSSITIS.

A number of conditions may be considered under this heading. The most convenient arrangement is that adopted by Butlin[6]. He includes the following:

1. Erythema migrans.
2. The dyspeptic tongue.
3. Furrows and wrinkles.
4. Glossodynia exfoliativa.
5. Herpes.
6. Leukoplakia.
7. Black tongue.

Erythema Migrans (Wandering Rash, Geographical Tongue, Desquamative Exfoliative Glossitis).—Beside the names given above this disease has received a great number of designations. It is an uncommon condition, and occurs most particularly in young children. There is apparently no sex predisposition.

The disease appears on the margin or the dorsum of the tongue, especially near the tip of the organ, and always in front of the circumvallate papillæ. In some cases it is found upon the under surface, but when it is, this is a mere extension from a patch on the margin. It begins as one or several small patches, circular or oval in outline. Each patch is on a level with the glossal epidermis, is red, tender, and smooth, and has gray edges. Butlin[7] points out that the patch may have an appearance of elevation or depression, "according to the condition of the dorsum and the thickness of the fur." The redness of this area is due to the fact that the filiform papillæ have been cast off. Each of these patches enlarges with considerable rapidity and soon becomes a ring or an oval. As it spreads more, it usually comes to resemble a crescent on the dorsum, this being due to the fact that the other portions of the outline of the oval or ring have passed around the margin of the tongue. A fully developed patch is smooth and a little reddened in the center. Approaching the margin the redness becomes much more intense, and contrasts strongly with the color of the margin, which is gray or yellow. The margin is distinct and a little bit raised. Not unusually two rings that are spreading meet each other. When such is the case there seems to be a struggle for supremacy, in which one

or the other must give way. The margin of one finally gives way and the other margin progresses into that patch. Rings may also contract and finally disappear. New crops of these patches appear on portions of the tongue that have previously been unaffected, or on parts on which rings had existed, but all contracted and disappeared. If, in this disease, an undulating line separates the reddened margin of the tongue from a gray area on the dorsum, the condition is often spoken of as *geographical tongue*, because of the supposed resemblance of the undulating line to the lines on an outline map.

Erythema migrans is an extremely chronic condition, lasting for months, and even for years. The areas involved vary greatly in size from time to time. Sometimes the disease seems to be extensive, sometimes there seems to be but a limited portion of the tongue attacked. The subjective symptoms are so extremely slight—if, indeed, any exist—that the disease is usually discovered by accident, and it has, in most instances, lasted for a long time before it is noticed. If pain, salivation, or any other positive symptom existed it would be found at an earlier period. The cause of the condition is unknown. Parrot's view was that it is always due to syphilis, but this is now known to be erroneous. It is thought by some to be parasitic. Butlin[8] says that debility is the only condition "which can in any way be regarded as a cause, either predisposing or exciting."

Treatment.—Cleansing washes, with the administration of tonics, and at times of cod-liver oil.

The Dyspeptic Tongue.—In this condition the tongue is the seat of a subacute or chronic superficial glossitis. In the milder cases there is irritation without excoriation; in the more severe cases there is excoriation; and in the worst cases, ulceration may occur. The condition is met with in adults suffering severely with dyspepsia, and is far more common in those that are gouty. In a good many instances it develops from traumatism, such as a burn. Were the organ normal the effects of this traumatism would soon pass away, but when the predisposition to the dyspeptic tongue exists a subacute or chronic glossitis is established. Sometimes there appears to be a family predisposition to the dyspeptic tongue.[9] In the dyspeptic tongue there are raw and reddened areas on the dorsum, the filiform papillæ having been destroyed; the tip or the margins become smooth and red and completely devoid of filiform papillæ. Each of these areas looks as if it were raw, but, as a matter of fact, an epithelial layer still covers them, although it may be greatly thinned. The tissues around the area, when examined microscopically, show the evidences of chronic inflammation. In such an area a very slight injury will serve to produce excoriation or actual ulceration. Consequently, a person suffering with the dyspeptic tongue has attack after attack of acute soreness and excoriation.

Treatment.—In this condition, first of all, the dyspepsia must be treated by diet and drugs, and every effort must be made to amend any existing gouty tendency. Chlorate of potash is a very useful mouth

wash, and the tongue should be painted, night and morning, with a solution of chromic acid of a strength of 10 gr. to the ounce.

Furrows.—Furrows may normally exist in the tongue. The most common furrow is found in the midline of the dorsum. These natural furrows are always longitudinal in direction, and may be of considerable length, and the mucous membrane lining them is always devoid of papillæ. They are very liable to ulcerate when inflamed or injured.

Furrows may be created in the tongue by any area of chronic inflammation. Cracks and fissures are likely to form when the tongue is inflamed chronically. Such fissures are very painful, and are extremely slow to heal. They may be single or multiple, and may occur on any portion of the tongue. The multiple fissures frequently cross one another in the most irregular manner. A fissure that remains unhealed after a long period of time becomes a menace and may become carcinomatous.

Treatment.—Keep the mouth clean by frequently washing it with peroxid of hydrogen. Avoid irritant articles of food, excessive smoking, tobacco chewing, and the drinking of undiluted spirits. Once a day the edges of the fissure should be separated, and the fissure swabbed out with a dilute solution of nitrate of silver.

Glossodynia Exfoliativa.—This is a condition of chronic inflammation in which there is separation of the horny layer of the epidermis, and the disease is accompanied by violent neuralgic pain in the tongue. We find, here and there over the tongue, spots from which the horny layer is being cast off. Eating, talking, the taking of hot or cold drinks, or contact with any irritant causes violent pain.

Treatment.—Repeated painting with nitrate of silver has been recommended by some; others have used the cautery. I saw an engineer suffering with this condition on whom ordinary treatment had had no effect. He claimed that the chewing of tar-rope relieved his pain very greatly. He chewed tar-rope daily for a long period of time, and was finally cured.

Herpes of the Tongue.—By this term we mean a disease, recurrent in disposition, each attack being transitory in duration, and characterized by the formation of vesicles in the epidermis. The vesicles form with great rapidity, and each one of them is the center of an inflamed area. They soon rupture, and frequently become pustular before rupture. After rupture has taken place the raw surface is covered, or partly covered, by the horny layer of the epidermis, and this sore either heals rapidly or increases in size by ulceration.

Such attacks of herpes may occur again and again, and sometimes seem to be brought on by exposure to the inclemencies of the weather, by exhaustion, or by excess in alcohol or tobacco. Some believe that herpes most commonly arises in the victims of tertiary syphilis, although the lesion itself is certainly not syphilitic.

In some attacks of herpes there is practically no pain, but merely a sense of soreness; in some there is violent pain in the tongue. Sometimes herpes of the tongue is associated with herpes of the lips, cheeks,

and skin. As a rule, the vesicles are small, but now and then a case is seen in which bullæ actually form upon the tongue, and the condition is then called hydroa.

In treating herpes the diet should be carefully regulated, all indigestible and irritant matters being excluded. The bowels should be moved with calomel, followed by a saline, and cleansing mouth washes should be used at frequent intervals.

Leukoplakia (Leukoma, Leukokeratosis, Smokers' Patches, Psoriasis of the Tongue, Ichthyosis of the Tongue).[10]—Leukoplakia is a chronic superficial inflammation involving the mucous membrane of the mouth, and most commonly, that of the tongue. In many cases it involves the tongue alone; in others, it involves the tongue, the cheeks,

FIG. 371.—LEUKOPLAKIA OF EXTENSIVE DEVELOPMENT, IN A MAN AGED FORTY-FIVE, AND OF EIGHT YEARS' DURATION; HAS BEEN SUBJECT OF PSORIASIS FOR TWELVE YEARS; NEVER HAD SYPHILIS. (Stelwagon from Schwimmer.)

and the lips. It may begin on any part of the tongue, but most commonly does so on the dorsum and near the tip, usually to one side or the other. The appearance of an area of leukoplakia varies greatly according to the stage of development attained. This observation explains—at least, in part—the various names that have been given to the disease, and the numerous divergent descriptions that have been given of it. The term leukoplakia may be applied to a mere smokers' patch, red in color, on one side of the dorsum of the tongue near the tip, to a considerable white area of disease of the mucous membrane of the tongue, or to a condition in which there is an extensive affection of the mucous membrane of the lips, cheeks, and tongue. The trivial smokers' patch, however, is after all but the first stage of the widespread disease.

Cause.—The real cause of leukoplakia is unknown. Smoking is regarded as the most common cause. This is so well recognized that the earliest stage of leukoplakia is called a smokers' patch. The fact that the disease is much more common among men than among women might be thought to lend confirmation to this view, but leukoplakia does occur in women, and it has been known to arise in many cases in persons that have never used tobacco. Hence, we are justified only in regarding tobacco as an exciting cause, though it is certainly the most common exciting cause. A smoker, like all the rest of the human race, is a man who falls into certain definite habits, and he gets into the habit of holding a cigar or a pipe in a particular way, just as one gets into a habit of wearing the hat at a particular slant. When leukoplakia arises in a smoker the first patch begins at the point that the pipe-stem or the cigar habitually touches, or where the smoke of the pipe or the cigar first impinges upon the tongue.

Some writers have maintained that leukoplakia occurs only in syphilitics—not in the victims of secondary syphilis, but in individuals that have had syphilis years before and have been thought to have been cured. It is now known that leukoplakia may occur in persons that have never had syphilis. It is, however, much more commonly found in those that have had this disease than in those that have always been free from it. The proneness of the old syphilitic to suffer from leukoplakia may be due to the fact that the nutrition and sensitiveness of the mucous membrane have been altered by numerous antecedent syphilitic lesions, a predisposition to chronic inflammation having thus been established. It may be due to the fact that the administration of mercury over a long period has produced many attacks of aphthous ulceration and, hence, prolonged irritation, or it may be that the victims of syphilis, constantly apprehending trouble, inspect the tongue and mouth at frequent intervals, and so discover quickly a lesion that other men might never discover or might at least possess for months or years without suspecting its existence. If the latter view is the true one, it would mean that leukoplakia is not more common in syphilitics, but is more certainly discovered because the disease in ordinary persons frequently lasts a very long time before it is discovered. My own conviction is, however, that whereas this latter fact may account for some of the cases among syphilitics, there is a distinct predisposition to leukoplakia in those that have suffered with syphilitic disease.

There is some evidence that gout and rheumatism predispose more or less to leukoplakia. Occasionally it is associated with psoriasis or other skin eruptions. Gastrointestinal catarrh seems to exercise some predisposing influence. The only positively known facts about its causation, however, seem to be that prolonged irritation in some persons, especially syphilitics, tends to cause the disease, and that the most common elements acting as exciting causes are smoking, drinking raw spirits, and eating irritating and strongly-seasoned food.

Pathology (Fig. 372).—There has been much dispute as to whether or not the disease is a real inflammation, but the evidence seems strongly

in favor of its being so. There is a proliferation of the horny layers of the stratified epithelium of the tongue (Fig. 373). The smooth white patches that form are devoid of papillæ, and are covered with a very thin layer of corneous epidermis. Commonly the cells of the Malpighian layer undergo multiplication, leukocytes gather beneath the epithelium, and the papillæ diminish in size and finally disappear. Eventually a scar forms beneath the surface epithelium. The area suffers from repeated attacks of inflammation, acute or subacute in character, and induced by the contact of various irritants. The more numerous these attacks of inflammation have been, the larger and the more definite the subepithelial scar becomes. In some cases the corneous layer of epithelium undergoes very great thickening, the other changes being identical with

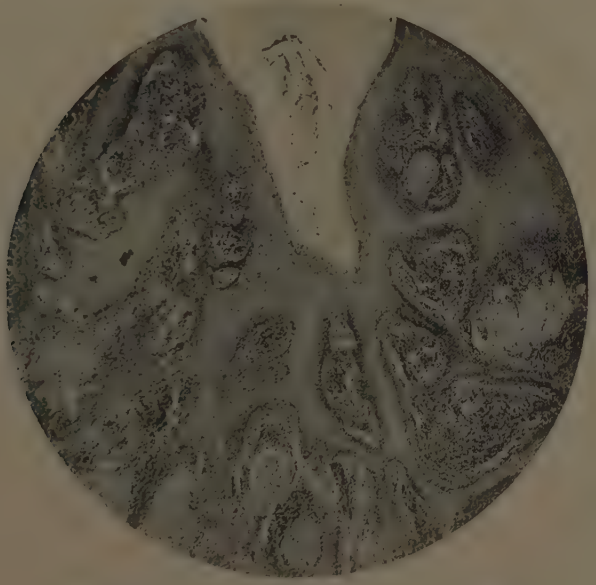

FIG. 372.—LEUKOPLAKIA LINGUÆ. (M. B. Hartzell.)

those described above. It has been pointed out by Butlin that just above the Malpighian layer in all cases the cells show degenerative changes.

Symptoms.—This disease is very unusual before the age of twenty years, though Hartzell [11] has reported a case in a girl of only eleven. In the majority of cases the early stage of the disease is not observed by a surgeon. It begins as a scarcely visible, reddened patch. In this patch the papillæ are sometimes more distinct than is normal, but usually they seem to have been removed. The patch looks a little depressed, because it is surrounded by a marked fur on the sound portions of the tongue. It is covered with a thin, brownish or whitish crust which at times peels away. Sauces, pickles, highly seasoned food, raw spirits, and smoking produce a sensation of irritation or soreness.

The incipient stage lasts for many months. Slowly and gradually such a patch undergoes evolution into a smooth, opalescent, or distinctly white area. There may be one, several, or many such areas, and they vary greatly in shape. A patch may be round, oval, or irregular, occasionally linear or crescentic. Patches frequently run together and form larger patches.

The disease usually begins upon the tongue, and the tongue alone may be involved, but the cheek or lips may come to be involved. It may begin upon the cheek or lips, and the tongue may remain free or may subsequently become involved. The color of the area is usually bluish-white. The patch is level with the surrounding surface, and between the two there is frequently a very fine line of hyperemia. The

FIG. 373.—LEUKOPLAKIA LINGUÆ. (M. B. Hartzell.)
Showing increase in thickness of corneous layer of mucous membrane.

appearance of the patch may be altered from time to time by attacks of acute inflammation, such attacks causing the formation of a raw surface, cracks, or fissures, and repeated attacks inevitably leading to thickening. The taking of any irritant material into the mouth may produce attacks of acute inflammation. In old cases the submucosa becomes definitely thickened, and the patch is then found to be rigid and inelastic. The surface of an old patch peels off and often becomes warty. Cracks or excoriations may form. Sometimes a patch ulcerates, and in some cases cancer develops.

While one patch or several patches are going through the above-mentioned changes new patches may be appearing here and there in the buccal cavity. Some patches remain apparently stationary for

years and never attain to marked thickening or ulceration. An area of leukoplakia that is not ulcerated is free from pain, unless irritants are applied. An ulcerated area is continuously sore. Any area, ulcerated or nonulcerated, is sensitive on the application of irritants, such as sauces, pepper, or hot drinks. In some of the ulcerated cases the pain is very severe.

Leukoplakia, when once well-established, is an incurable condition. There can be no question but that cancer may arise in an area of leukoplakia. A papillomatous growth forms and becomes cancerous, a fissure or excoriation becomes epitheliomatous, or an induration due to malignant disease forms and ulcerates. What per cent. of the cases eventuate in cancer is not known, but the danger is quite enough to make it imperative that the victim of leukoplakia should protect himself in every way possible from irritation of the buccal cavity.

Diagnosis.—The mode of origin, the history of the case, and the tardy course are significant. A syphilitic mucous patch forms quickly, not slowly; its duration is brief, not prolonged; it is soft and not indurated. Further, mucous patches are preceded or followed by, or are contemporaneous with, other syphilitic lesions.

Treatment.—Every effort must be made to limit irritation of the diseased area, in order to retard the progress of the malady and to lessen the undoubted danger of carcinoma. The teeth should be put in and maintained in perfect order, and should be cleansed carefully twice a day. After each meal the mouth should be rinsed with dilute peroxid of hydrogen. Irritant articles of food should be rigorously excluded from the diet; smoking or chewing, if either is practised, should be abandoned; spirit drinking should be forbidden. The digestion should be carefully regulated, a daily movement of the bowels should be secured, and if gouty or rheumatic symptoms arise, they call for appropriate remedies. Every other day the patches may be painted with glycerite of tannic acid. When thickening of the epithelium takes place or when excoriation occurs, it is best to apply, from time to time, a solution of chromic acid of a strength of 10 gr. to the ounce. Butlin [12] has shown the value of ointments rubbed in night and morning; they relieve the distressing night dryness. He uses as a basis 2 dr. of vaselin with 6 dr. of lanolin and adds borax, or eucalyptus, or some other drug. Caustics, for instance nitrate of silver, should not be used. The continued use of caustics increases the tendency to cancer. An application strongly commended by Brockhardt is balsam of Peru. He applies it every day or every other day, and requires the patient to wash his mouth from six to twelve times a day with salt solution of a strength of from $\frac{1}{2}$ to 3 per cent.

I have never seen any evidence that antisyphilitic treatment does any good and I have never seen a well-established case cured by any medicine, applied locally or taken internally.

Can surgery do any good? When epithelial thickening begins applications of the galvanocautery seem sometimes to retard the progress of the disease. Butlin, after a large experience, has reached

the conclusion that in the early stages of leukoplakia it is not wise to cut out the patch, because the resulting scar will prove quite as troublesome as the patch, and because the removal of the patch does not prevent the development of the disease about the scar. If, however, a thickened, circumscribed patch exists, he advises excision. When an indurated area forms, when an ulcer persists, or when a papillomatous growth forms, excision must be employed at once, because in any one of these cases it is practically certain that cancer has already begun.

Black Tongue (Hairy Tongue, Hyperkeratosis Linguæ, Nigritie de la Langue).—This condition is due to an excessive growth of the filiform papillæ. Genuine hairs are never formed. The diseased area is brown or black, the color being an accident and not the essential part of the disease, and resulting from bacteria which adhere to the exuberant papillæ. The diseased area is usually, but not always, in the midline of the dorsum, in front of the circumvallate papillæ. The area gradually enlarges and in the course of a number of weeks spreads widely over the dorsum of the tongue. The disease tends to spontaneously disappear, but does so very slowly after months or even years of activity. During disappearance the color fades from the periphery toward the center.

The disease is seldom met with, causes no subjective symptoms, and is of trivial clinical importance. Treatment is of no avail.

ULCERS OF THE TONGUE.[13]

Ulceration of the tongue frequently occurs. An ulcer may arise from a wound, particularly a wound inflicted by the teeth, from the irritation of rough, sharp-edged, or carious teeth, from the taking of very hot articles of food or drink, from chronic glossitis, from indigestion, from tuberculosis, from syphilis, from cancer, from the administration of mercury, and from other causes. Ulcers of the tongue, with the exception of syphilitic ulcers and of many tuberculous ulcers, are purely local diseases beginning in the glossal mucosa. Butlin's classification of ulcers of the tongue is practically useful. It is as follows:

1. Simple, including the dyspeptic. 2. Herpetic, or aphthous. 3. Traumatic. 4. Ulcers of the frenum from coughing. 5. Mercurial. 6. Tuberculous. 7. Syphilitic.

Simple Ulcers.—By a simple ulcer is meant a local ulceration, the cause of which is uncertain. The majority of such ulcers are due to repeated trivial, but unidentified injuries or to slight, prolonged, but unrecognized irritation. If a causative injury is recognized the ulcer is then classified as a traumatic ulcer. In leukoplakia, excoriations are very common and genuine ulcers not infrequently form. The ulcers of leukoplakia are probably due to irritation or injury acting upon tissue of greatly lessened resistance.

A simple ulcer is an indolent, chronic, and usually painful sore, of irregular shape, the edges of which are thick, but seldom hard, and the raw surface of which is destitute of granulations. The pain is greatly

increased by taking into the mouth any hot or irritating article, and it is sometimes increased by movements of the tongue. At times the edges of a chronic simple ulcer become greatly thickened and indurated. In such a case the raw surface is dry and glazed and the very great amount of contracting scar-tissue at the base and edges pulls the surrounding healthy tissue in toward the ulcer, and thus corrugates and wrinkles it. Ordinary simple ulcers can usually be healed readily. Chronic simple ulcer, even when thickened, may heal, but the scar is liable to break down from comparatively trivial irritation or injury.

Treatment.—Any person with chronic inflammation of the tongue is likely to suffer from ulcer formation, and in order to prevent such a misfortune he must be most judicious in diet and habits, and must take pains to avoid every causative irritation. Smoking, spirit drinking, the taking of very hot or very cold materials into the mouth, and the use of vinegar, mustard, pepper, etc., are to be forbidden. Carious teeth must be removed and any sharp edge of a tooth must be filed away. The teeth must be kept scrupulously clean and a cleansing mouth wash should be used several times a day. When an ulcer forms the same general treatment should be followed, and in addition the sore surface should be painted once a day with a solution of chromic acid of a strength of 5 gr. to the ounce. A mouth wash of chlorate of potash should also be employed.

Some indolent sores are stimulated to healing by touching them with alum. Nitrate of silver or other caustics should never be used, as the irritation induced by their frequent application may result in cancer. There are few things more dangerous than the frequent application of caustics to the tongue. The chronic ulcer with indurated and greatly thickened edges calls for immediate excision, the knife being carried well wide of the ulcer's edges and well beneath its floor, the incision being elliptical, if possible, and the edges being brought together with silk sutures.

Dyspeptic Ulcers.—A dyspeptic ulcer, as has previously been stated, is a form of simple ulcer. Such ulcers occur particularly on the middle of the dorsum of the tongue, near its tip, but they are occasionally met with on the under surface of the tongue. Dyspeptic ulceration is invariably multiple, and the ulcers are of small size, very superficial, and extremely irritable. Such ulcers sometimes form in adults, but are infinitely more common in children. Any indiscretion in diet may be followed by excoriations, and any excoriation may become an ulcer. Some persons suffer with a sore mouth of this type after eating nuts; others after eating certain fruits, etc. There are many idiosyncrasies in this respect.

Treatment.—The condition is usually rapidly recovered from after the administration of a saline purge. It, however, tends strongly to recur, and if it continues to recur the patient is treated by a rigid regulation of the diet, by keeping the bowels open, by the use of a mouth wash containing chlorate of potash, and by painting the sore surface now and then with chromic acid of a strength of 5 gr. to the ounce.

Herpetic or Aphthous Ulcers.—These ulcers are not limited to the tongue, but develop at the same time on the lips and cheeks. Some persons have considered that they are transferred by contagion, but the grounds for this belief seem insufficient. They are vastly more common in children than in adults. The condition as met with in adults has been discussed under the head of Herpetic Inflammation of the Tongue; the condition as it arises in children will be considered here.

According to Butlin, it particularly tends to arise between the ages of six months and three years, and it often follows an exanthematous fever. Many cases, however, arise entirely independent of any antecedent exanthem. The condition begins with elevation of temperature, malaise, and gastro-intestinal disturbance. A crop of vesicles appears on the tongue and cheeks after an uncertain length of time. The area containing the vesicles is red, irritated, and painful. The vesicles soon rupture and expose diminutive, superficial, round, or oval ulcers, with punched-out edges, and with a whitish slough adherent to each ulcer. The parts about each ulcer are red from inflammation. There are a varying number of vesicles in this condition, but seldom more than fifteen or twenty, and the ulcers that form heal in a few days. There may be but one attack of this strange condition, but usually attack after attack occurs during many weeks.

Treatment.—In this condition it is advisable to avoid the administration of mercury, because of the possibility that gangrenous stomatitis may supervene. A saline purge should be administered and the bowels should be kept soluble during the continuance of the trouble. The patient should be fed with the plainest of diets, and there is nothing better than milk and eggs. The sores should be wiped off at frequent intervals with a solution of boracic acid and a mouth wash of chlorate of potash should be used. If healing is tardy, each sore should be touched every day or so with alum. Internally, the syrup of iodid of iron is thought to be of service.

Traumatic Ulcers of the Tongue.—Traumatic ulcers are due to wounds or persistent irritation. A discussion of wounds and their treatment will be found in a previous section. In this section we shall describe ulcers due to irritation.

The most frequent causes of such ulcers are sharp-edged teeth, rough and decaying teeth, and ill-fitting plates of artificial teeth. A traumatic ulcer is situated on the edge or the tip of the tongue, and there is the greatest possible variability among different traumatic ulcers in extent and in severity. There may be a mere trivial excoriation, a distinct though small sore, or an ulcer of large size.

A traumatic ulcer is shallow and solitary, irregular in outline, and with precipitous edges. Frequently a slough adheres to the margin. The tissue about the ulcer is red and is swollen with edema. The entire tongue is coated and the breath is offensive, but the lymph-glands below the jaw are not enlarged unless the inflammation is extremely violent. In a recent case the edges, even though they may be thickened,

are soft; in an older case they are sometimes indurated. In a very chronic case there is less surrounding inflammation, but much more fibrous tissue at the edges of the ulcer. Hence the edges become distinctly indurated. In some old cases the area of indurated thickening is very extensive, and in such a case the sore itself is apt to be trivial in size. A traumatic ulcer may form on the tongue of a person in perfect health, but in the majority of cases of the disease it is found that the health is impaired and the digestion disordered.

Diagnosis.—A recent traumatic ulcer may be mistaken for a syphilitic sore, but a significant fact is the situation of the ulcer. It is placed in close contiguity to a diseased tooth, a jagged tooth, or the edge of an ill-adjusted plate, and this location indicates the real cause of the trouble. Again, the general evidences of syphilis are absent, induration is absent or trivial, the adjacent parts are red and edematous, and an ulcer forms very rapidly. If the traumatic ulcer is chronic and much indurated the diagnosis is always difficult and sometimes impossible. Occasionally there may be confusion as to whether one is dealing with a chancre or with a traumatic ulcer. A chancre is very definitely circumscribed, and has much greater induration, the lymph-glands are invariably enlarged, and the sore is practically always at or very near the tip of the tongue. A gumma arises in the submucous tissue or in the substance of the tongue, and a sore forms only when rupture has occurred. Hence, the resulting ulcer is near the center of the tongue, is small in circumference, but of great depth, and the edges of the sore overhang. The area of disease beyond the apparent ulcer is very large and the induration is extremely great. Often more than one gumma exists, and usually there are other evidences of syphilis, or at least there is a history of syphilis. The gummatous ulcer is covered with an adherent slough.

A tuberculous ulcer occurs particularly in young persons. It is irregular in outline, and is often quite free from induration. It is necessary to remember that the fissured ulcer is indurated. The edges of a tuberculous ulcer are thin and purplish, usually distinct, and are seldom undermined. The surrounding parts show no evidence of inflammation. The ulcer is very deep and is covered with edematous granulations or a greenish slough, perhaps showing here and there a spot of redness. Distinct tuberculous foci may be observed in other parts of the tongue. In most of the victims of tuberculous ulcer of the tongue there is tuberculous disease of some other structure, especially of the larynx or lungs.

A chronic ulcer with indurated edges is liable to be confused with carcinoma, and a chronic ulcer may at any time become carcinomatous, the growth beginning at some point on the edge of the ulcer. Carcinoma, like a chronic ulcer, is markedly indurated. In a young person with an ulcer on the tongue one may be reasonably sure, from a consideration of the age alone, that the condition is not cancer, and this opinion will be strengthened if one finds an obvious cause for a traumatic ulcer. If, however, the person is more than thirty-five or forty

years of age a knowledge of the age is of no help whatever in reaching a conclusion, as either condition may exist at that time of life.

In every doubtful case a piece of considerable size should be removed for microscopic study. This section should include a portion of the ulcer, a portion of the indurated margin of the ulcer, and a portion of the apparently sound tissue beyond the ulcer. A section that includes only a portion of the ulcer and a portion of the margin may lead to erroneous conclusions. In two instances in which a small section had been examined I received the report that cancer existed, yet in both cases local excision was followed by cure, and a careful study of the entire specimen removed showed that the disease was not carcinoma. If the apparently sound tissue beyond the ulcer is found to be infiltrated with epithelial cells the diagnosis of cancer is assured. It is most important in ulcers of the tongue to make a certain diagnosis early, for if cancer exists palliative treatment must immediately be abandoned and free excision practised. The chance for confusion exists only in a case of beginning cancer. One cannot confuse a traumatic ulcer with a well-advanced cancer. In a well-advanced cancer the diagnosis is made clear by the great induration, the progressive enlargement of the ulcer, the severe pain, and the glandular enlargement.

Treatment.—Most traumatic ulcers can be cured rapidly by proper treatment. The causative irritation must be sought for and removed. Carious teeth should be filled or extracted, rough points or sharp edges on the teeth should be filed away, and an ill-fitting plate should be cast aside. Most of these cases will recover promptly after the removal of the cause and the adoption of some simple means of treatment. The teeth must be kept clean; a mouth wash of chlorate of potash should be used at frequent intervals; the bowels should be moved daily; all irritant and indigestible matter should be excluded from the diet; and the sore should be touched once a day with chromic acid of a strength of 5 gr. to the ounce. If a suspicious ulcer does not promptly heal, particularly if it is indurated and if the patient is more than thirty-five years of age extirpation should be practised. The incisions about the ulcer should be elliptical, should be made well wide of the sore, and should pass underneath the sore into the muscular structure of the tongue. The resulting wound should, of course, be sutured. If it is found that carcinoma has begun, free excision is demanded.

Ulcer of the Frenum.—Ulcer of the frenum not unusually occurs in children with whooping-cough, and is produced by rubbing on the teeth during spells of coughing. Such an ulcer is irregular in outline, small in size, superficial, and sloughy, and is usually recovered from promptly on the abatement of the violent paroxysms.

Mercurial Ulcer.—This occurs in those that are ptyalized. The entire tongue is greatly swollen. There are usually several or many ulcers, rather than one, each ulcer being shallow, irregular in outline, and surrounded by reddened tissue, Some mercurial ulcers tend to spread both laterally and in depth. Sometimes extensive ulceration

results from sloughing. In mercurial ulceration all the other symptoms of ptyalism are found.

Treatment.—At once abandon the administration of mercury. Do not give any iodid of potassium, as this makes the ptyalism worse. Use a mouth wash of chlorate of potash or permanganate of potash, and administer tonics, food, and stimulants. If the swelling continues, astringents, particularly the nitrate of silver, may be used upon the tongue. The flow of saliva may be considerably lessened by the administration of tincture of belladonna.

Tuberculous Ulcer of the Tongue.—See Tuberculosis of the Tongue.

Syphilitic Ulcer of the Tongue.—See Syphilis of the Tongue, p. 680.

TUBERCULOSIS OF THE TONGUE.

The tongue is seldom the seat of tuberculosis, in spite of the great numbers of bacilli that must constantly pass over it. Infection may arise through infected sputum, through the introduction of bacilli with food or on the fingers, or by way of the blood from some distant tuberculous focus. Lupus of the skin may enter the mouth from the cutaneous surface and finally come to involve the tongue.

Tuberculosis of the tongue is much more common in men than in women, and tuberculous ulcers are seen most particularly in persons between the ages of forty and fifty years. A great majority of the tuberculous ulcers occur in the victims of tuberculosis in other parts, especially the larynx or the lungs, but local tuberculosis does occasionally arise in the tongue. It may be met with as a cold abscess, a nodule or tuberculoma, a papilloma, or an ulcer.

Cold Abscess.—A cold abscess arises in the substance of the dorsum of the tongue. It is placed beneath the mucosa, which is, in many cases, movable over it. It is a smooth, circumscribed mass, round or oval in outline, seldom larger than a hazelnut, not the seat of pain or tenderness, and not translucent. Cold abscess of the tongue is a very chronic condition and may remain apparently unchanged for months or even years. It may rupture, and when it does so it forms an ulcer.

Treatment.—Incision and cureting.

The Tuberculous Nodule, or Tuberculoma.—This is a solitary tuberculous focus formed by the aggregation of numerous minute tubercles. It occurs particularly in young subjects and on the edge or tip of the tongue. The mucous membrane above it is of a yellowish color and the mucous membrane around it is red. The nodule is seldom larger than a pea. It is irregular in outline, indurated, and placed beneath the epithelium. It tends rather strongly to soften into an abscess or to break into an ulcer. In some cases a nodule breaks open by means of a short fissure, which is either straight or branched. A *fissured ulcer* is thus formed. If the edges of such a fissure are retracted an extensive ulcer with overhanging margins and caseating surfaces is exposed. In a cure of tuberculous fissure the associated lymph-

glands are frequently enlarged and material scraped from the ulcerated surface may be found to contain tubercle bacilli. The induration suggests cancer, but for the very small size of the surface cleft, the way in which the edges can be spread apart, and the fact that the patient is probably young. Bacteriologic study may give important information. In order to make the diagnosis from syphilis it may be necessary to apply the therapeutic test. When the epithelium of the tongue is elevated at points by tuberculous infiltration, fissures form between the elevations. These elevations are often called *tuberculous papillomata.*

Treatment.—The best treatment is removal by means of elliptical incisions.

Tuberculous Ulcers.—Tuberculous ulceration of the tongue may present itself in any one of three forms: (1) Fissured ulcers or fissures. These were considered under the head of tuberculoma. (2) Lupus of the tongue. (3) Tuberculous ulcers proper.

Lupus of the Tongue.—This is never a primary condition, but arises occasionally, though very seldom, during the progress of lupus of the skin. In some cases the mouth and the pharynx, and occasionally the larynx, are affected as well as the tongue. When the disease does occur, it is found in young persons, particularly young girls. The diseased area is a crusted sore, irregular in outline and devoid of induration, the edges being undermined here and there, and the surrounding structures, though free from redness and other signs of inflammation, showing minute caseous foci. If the crust is lifted off a nodular sore is exposed, the color of which is distinctly pinkish. The disease is so rare that its very existence was long doubted, but Butlin, Leloir, and others have reported undoubted cases. The diagnosis may be confirmed by bacteriologic studies and by inoculation experiments on animals.

Treatment.—Treatment seems to be of little avail. It consists in frequently using cleansing washes, rubbing iodoform into the sore several times a day, perhaps using the *x*-rays, and in some cases employing tuberculin.

Tuberculous Ulcers Proper.—A typical tuberculous ulcer of the tongue is a sore with an uneven floor, covered with pale and edematous granulations, and discharging a thick and yellowish material. As a rule, there is little or no induration. The edges are clearly defined, irregular, usually not elevated, not everted, and seldom undermined. The parts about the ulcer do not exhibit signs of inflammation, but usually contain caseous foci. Sometimes such ulcers are primary, but in the vast majority of cases they are secondary, particularly to disease of the lungs or of the larynx. There may be a single sore, but in many cases there are two or several of them. They may occur on any part of the tongue, but are most commonly met with at the tip or on the edges. They may arise at any age and are most frequent in males and in young adults.

When the ulceration is just beginning it produces very little annoyance, but sooner or later pain and tenderness develop, progressively increase with the progress of the case, and finally become severe or even excruciating. After the sore has lasted for a considerable length of

time salivation occurs. The general health perceptibly fails and destructive sloughing is liable to take place at any time. In most cases the lymphatic glands beneath the jaw enlarge, and a careful examination may detect tuberculous disease of some other part.

A tuberculous ulcer of the tongue sometimes heals, but even when it does so, it has a strong tendency to break down. In a large majority of such cases the patient dies within two years.

The diagnosis is often difficult. The ulcer may be confused with the deep gummatous ulcer of tertiary syphilis or with cancer. The deep gummatous ulcer of tertiary syphilis is more likely to occur near the center of the tongue than at the edge. This ulcer is deep, its edges are undermined, it is covered with an adherent slough, there is an extensive area of diseases about it, the sore is much indurated, adjacent lymphatic glands are not enlarged, and usually other evidences of syphilis can be discovered. In doubtful cases the therapeutic test must be applied. Bacteriologic studies and inoculation experiments may serve to show that the sore is not tuberculous.

There is no doubt that the tuberculous ulcer is occasionally confused with cancer. Both of these conditions tend to appear on the edge or tip of the tongue, but the tuberculous ulcer is usually devoid of induration. It is covered with pale and edematous granulations, and the mucous membrane about it exhibits small caseous foci. It is most common in young persons. Usually a tuberculous focus can be discovered in some other part, and the diagnosis may be definitely determined by bacteriologic studies, inoculation experiments, and the microscopic examination of sections that have been removed.

Treatment.—A primary tuberculous ulcer should be extirpated and the glands beneath the jaw should be removed. I have performed this operation on two cases. The first, an advanced case, was followed by great amelioration in the suffering of the patient, although he finally died of pulmonary tuberculosis, which was not detectible at the time of the operation. The second case, in which no other tuberculous focus was discovered, remained well for a number of months, when local recurrence took place.

In a secondary tuberculous ulcer of the tongue one may operate to relieve suffering, although in such a condition there is no thought of curing the patient of his tuberculosis. If in any case operation is refused or is considered inadvisable, all sources of irritation should be kept away from the sore—all irritating articles of food, very hot food, or food that requires much chewing should be avoided. Tobacco and spirit drinking should be given up. Caustics should never be used. Cleansing and astringent mouth washes should be used a number of times a day and iodoform should be rubbed into the sore several times daily. If the pain is severe, Butlin adds a little morphin to the iodoform powder. He uses the following formula: Finely powdered iodoform, 1 gr.; morphin, $\frac{1}{6}$ gr. to $\frac{1}{2}$ gr.; and borax, 3 gr. Before applying the powder he cleanses the surface of the ulcer with a piece of absorbent cotton, and then dusts the sore thickly with the powder or

blows it upon the sore through a glass tube. He makes these applications three or four times a day, watching carefully for any constitutional effect from the morphia.

SYPHILIS OF THE TONGUE.

The tongue may be affected by primary, secondary, or tertiary syphilis. The initial lesion of syphilis occurs at or near the tip of the tongue. It is rapid in formation and distinctly circumscribed, has strongly indurated edges, pursues a slow and painless course, and is red, uneven, and often fissured. Enlarged glands will be palpable almost as soon as the ulcer appears. Other signs of syphilis exist or will exist, and antisyphilitic treatment causes the rapid disappearance of the condition.

In secondary syphilis mucous patches attack particularly the tip and the sides of the tongue. They are associated with patches elsewhere within the mouth and with other and distant signs of secondary syphilis. These patches become very sore if irritated. Fissures may form and the entire tongue may inflame.

In tertiary syphilis an ulcer that forms results from a broken-down gumma. The superficial tertiary ulcer affects the mucous membrane. The sore is indurated and small, has vertical edges, and is covered with a white slough. It is especially common on the edge or the tip of the tongue. Such sores are frequently multiple or are at least usually bilateral. The deeper gummatous ulcer arises from what has been called a parenchymatous gumma. Such a gumma springs from the connective tissue among the muscles of the tongue. It begins as a lump beneath the mucous membrane. This gradually increases in size and finally a portion of the mucous membrane gives way, exposing a cavity. The cavity is lined with adherent slough, its edges are overhanging, and it is surrounded by widespread disease and much induration. A gummatous ulcer is productive of little or no pain, and in neither form of the condition are there enlarged lymphatic glands.

Treatment.—A gummatous ulcer is treated by the use of cleansing mouth washes and by the administration of antisyphilitic treatment, which must comprise small doses of the bichlorid of mercury and advancing doses of the iodid of potassium.

In some cases the sore should be cureted, in others it should be touched daily with chromic acid, 5 gr. to the ounce.

Leprosy.—The victims of leprosy may develop tubercles upon the tongue.

Actinomycosis.—Cases of actinomycosis of the tongue have been reported.

Trichinosis.—Cases of this condition have been reported.

INFLAMMATION OF THE LINGUAL TONSIL.

Behind the foramen cecum and sulcus terminalis the mucous membrane of the tongue contains numbers of lymphoid follicles. These follicles in the aggregate are often called the lingual tonsil.

The lymphoid follicles sometimes become the seat of a hypertrophy. In this condition there is chronic inflammation of the lingual tonsil associated with chronic pharyngitis and enlargement of the faucial tonsils. The enlarged follicles are readily seen by means of the laryngeal mirror. The best way to remove the enlarged follicles is by means of the electric cautery.

The lingual tonsil may undergo acute inflammation as a result of streptococcic infection or of diphtheria. Sometimes it becomes inflamed in cases of ordinary quinsy. Inflammation produces great swelling of the base of the tongue and is a dangerous condition because of the possibility that it may cause edema of the epiglottis and glottis.

It is particularly apt to occur in anemic individuals who overuse the voice by singing, lecturing, auctioneering, or public speaking. It causes cough, difficult and painful swallowing, and perhaps shortness of breath. The laryngeal mirror brings the enlarged follicles into view. Abscess may form.

If abscess does not exist the treatment consists in destroying the tonsil with the galvanocautery, and then in improving the general health and protecting the part from irritations (overuse of voice, tobacco smoke, alcoholic liquors, and irritating articles of diet). If an abscess forms it must be incised. During the operation the patient lies upon the side with the head lower than the body. This precaution prevents the pus from flowing into the larynx and perhaps choking the patient.

Thyroglossal Cysts.—See page 280.

HYPERTROPHY OF THE TONGUE OR MACROGLOSSIA.

The tongue or one-half of it may remain permanently enlarged after an attack of acute inflammation or as a result of chronic inflammation. This condition produces little or no annoyance, is not true macroglossia, and is called *inflammatory hypertrophy*. Multiple gummata may cause great enlargement of the tongue, and in some cases, even after the disappearance of the gummata, the tongue may remain enlarged. This condition is called *syphilitic hypertrophy*. Hydrargyrism may be responsible for hypertrophy.

There is a form of hypertrophy in which all of the muscles or the muscles of one-half of the tongue enlarge. This condition of muscular macroglossia is particularly common in idiots, though it is occasionally met with in normal children. In a case of sporadic cretinism in the Philadelphia Hospital the tongue hung far out of the mouth. Most of these patients can take food, but if the tongue seriously interferes with eating, a large V-shaped piece should be removed. Butlin points out that an operation is necessary if the large tongue so obstructs breathing that sleep is greatly interfered with, and also if the intellect is developing, but the large tongue renders speech impossible.

True Macroglossia.—By this term we mean a cavernous lymph-

angioma of the submucous connective tissue of the tongue. In many cases the muscles are also involved. It is a congenital condition, and even when it appears to begin later in life (as it sometimes does after an injury) it is probable that some deeply placed and unrecognizable lymphangiomatous area had been present since birth and that the apparently causal injury did not inaugurate the disease, but simply stimulated rapid growth.

The disease affects particularly the anterior three-fourths of the tongue. At birth nearly all of the tongue may be lymphangiomatous or but a portion of it, or a lymphatic nevus may exist. Such a nevus is a collection of vesicles containing lymph, the outlines of the vesicles being rendered distinct by visible blood-vessels between them. There may be a small group of such vesicles, many of them, or almost the entire tongue may be covered with them. Such vesicles are thin-walled and dilated lymph-vessels (lymphangiectasis). In most cases of macroglossia growth is observed soon after birth, but in some unusual cases the condition remains stationary until the accession of puberty, when growth usually begins. Growth is for long periods very gradual: being for a time rapid after an attack of inflammation, and becoming again slow after the inflammation subsides. At times the condition seems to remain stationary for a long period. As the tongue grows it finally becomes so large as to protrude from the mouth, the saliva dribbles constantly, the child never learns to speak at all or becomes able only to thickly mumble a few words. The position of the enlarged organ between the teeth leads to its being pinched and bitten, and the teeth may make furrows or ulcers on it. The protrusion of the organ from the mouth exposes it to various extraneous irritations, and it becomes dry and cracked. As a result of injury by the teeth and of other irritations, attacks of glossitis occur and each attack goads the tumor to more rapid growth. The protrusion of the large mass between the teeth keeps the jaws forced widely apart, makes the incisor teeth project forward, and causes great deformity of the jaws.

Treatment.—An operation should be performed early. If the tongue is very large soon after birth an operation should be performed before the child has begun to try to talk. Operation is indicated before deformity of the jaws takes place. In any case operation may be rendered imperatively necessary because of difficulty in taking food and embarrassment of respiration when sleeping. The operation consists in removing a large V-shaped piece of the anterior part of the tongue. The sides of the wound are sutured together.

RANULA.

The term ranula is used to designate a cyst under the tongue, the cyst being due to obstruction of the duct of either a mucous gland or a salivary gland. The obstruction may be a congenital condition, may be due to a growth outside the duct, may be due to the entrance of a foreign body into the duct, but in a great majority of instances results

from inflammation of the duct and the formation of a plug of hardened mucus which often contains salts of lime. The obstruction is usually brought about gradually, and, strange to say, the duct inflammation is seldom secondary to any other inflammation or to any septic condition about the mouth. In what is known as *acute ranula* sudden and painful blocking of a salivary duct occurs during mastication. It is usually due to calculus and may be temporary or permanent. Sometimes intermittent blocking occurs. Ranula is most common in adults, but is occasionally met with in children. In an old ranula the gland atrophies.

Sublingual Ranula.—This is the form most often met with. It results from blocking of the ducts of Rivini or the ducts of Bartholin. This form of ranula occupies the floor of the mouth. It is a tense, thin-walled, fluctuating, translucent cyst, which does not project below the jaw. It may become so large as to make speech very difficult, to hinder swallowing, and to impede respiration. In some cases it is bilateral.

Submaxillary Ranula.—This is a rare condition which is due to the blocking of Wharton's duct. It bulges the floor of the mouth more externally than the other form and also appears beneath the jaw.

Incisive Ranula.—This appears under the frenum of the tongue, which structure is raised and spread out.

Ranula of the Glands of Nuhn and Blandin.—This form of ranula does not occupy the floor of the mouth, but is situated under the tip of the tongue.

Treatment.—Simple incision is never curative. A mucous ranula can be cured by removing most of the wall with scissors and suturing the edges of the small portion of wall left to the mucous membrane.

A salivary ranula requires excision. In most ranulas excision through the mouth is practical. If a submaxillary ranula bulges externally, removal should be effected through an incision below the jaw.

CYSTS AND TUMORS OF THE TONGUE.

Cysts.—*Parasitic cysts* occasionally form. *Mucous cysts* of the tongue proper are rare. They occur on the dorsum or sides, are seldom larger than a hazelnut; they are thin-walled, and fluctuate. Treatment is excision of as much of the wall as possible and cauterization of the portion left behind.

Dermoid Cysts.—Cysts of this character are occasionally encountered. These cysts arise in the floor of the mouth, usually in the median line, very seldom to one side. Such cysts lie between the geniohyoglossi muscles and are placed above the mylohyoid muscle. A dermoid cyst bulges the floor of the mouth and also appears beneath the body of the lower jaw. It grows progressively, and because of its size eventually interferes with respiration, speech, mastication, and deglutition. It is not bluish and translucent, as is a ranula, but is of a yellowish color. It does not fluctuate, but pits on pressure. A dermoid cyst may

inflame and even suppurate. If it ruptures or is incised a fistula may form.

Treatment.—The only proper treatment is excision, either through the mouth or through an incision below the jaw. In a great majority of cases the cyst will be found to be firmly attached to the periosteum of the lower jaw, to the hyoid bone, or both of these structures.

Innocent Tumors.—Innocent tumors of the tongue are comparatively rare.

Lipoma occasionally arises from the dorsum or edge of the tongue. It is a pedunculated growth and is treated by extirpation.

Fibroma is occasionally met with. It is usually pedunculated, but is sometimes sessile. A surface growth is easily recognized, but a deep-seated growth may be impossible of diagnosis. The treatment of fibroma is extirpation. *Keloid* is a very unusual lingual growth.

Angioma is not so unusual as are lipoma and fibroma. It may appear as a *simple nevus* or as a *cavernous angioma.*

Some of these growths are congenital, some are acquired. Congenital angiomata sometimes, though seldom, undergo spontaneous disappearance; acquired angiomata never disappear spontaneously.

Angiomata deeply placed in the tongue may be impossible of diagnosis. Surface angiomata are recognizable as practically identical in appearance with cutaneous angiomata. Cirsoid aneurysm is occasionally met with. Angiomata are dangerous because they are apt to give rise to severe hemorrhage.

Some angiomata are treated by excision, others by repeated cauterizations with the galvanocautery. In some cases it is necessary to tie the lingual arteries before undertaking any operation.

Cases of **chondroma** and **osteoma** have been reported.

Lymphangioma.—See Macroglossia.

Papilloma is not uncommonly seen upon the tongue. Papillomata are most common in young persons. They are growths of a warty appearance, some being soft and cauliflower-like, some hard and of more definite outline, but all being free from induration at the base. Papilloma strongly tends to become cancerous, especially if irritated by caustics or other irritants.

Adenoma is a very rare growth. It may develop from glandular substance and grow into the depth of the tongue. It usually grows outward and forms a growth like a polypus.[14]

Lingual Goiter.—See Goiter.

MALIGNANT TUMORS OF THE TONGUE.

Sarcoma.—True primary lingual sarcoma is a very rare condition. Round-celled sarcoma is more common and much more malignant than a spindle-celled growth. The spindle-celled neoplasm and the tumor composed of large round cells do not involve adjacent glands. The small round-celled growth does involve adjacent glands.

Sarcoma arises in the substance of the tongue. The duration of

life depends upon the rate of growth and metastasis and these depend upon the cellular composition. A small, round-celled growth may be fatal in a few months. In less malignant growths life may be prolonged for some years or a cure may perhaps be affected by operation.

The treatment is by free extirpation. If the case is seen early it may not be necessary to remove the entire tongue, in more advanced cases this should certainly be done. In growths which develop rapidly the glands should be removed from beneath the jaw.

Carcinoma of the Tongue.—Carcinoma of the tongue is by no means an uncommon disease. It probably represents about 8 per cent. of all cancers that are encountered in the male sex. The condition is vastly more common among men than among women, from 80 to 85 per cent. of the cases occurring among males. The reason for this

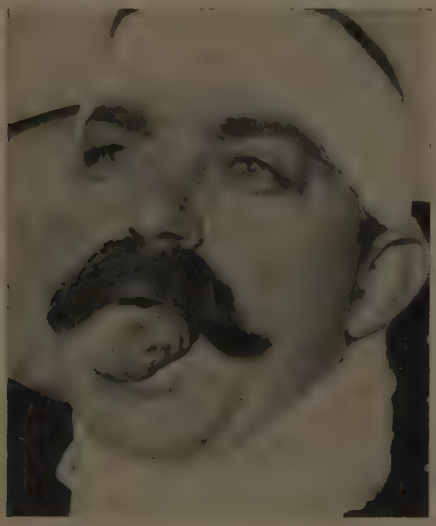

FIG. 374.—CARCINOMA OF THE TONGUE.

preponderance in the male sex has been much disputed. It is commonly believed to be due to the fact that more men than women use alcohol and tobacco.

Primary carcinoma of the tongue seldom begins at the tip of that organ, and more seldom still on the dorsum. In the majority of the cases it begins on the side, and much more commonly starts on the anterior two-thirds of the tongue than on the posterior portion.

It is a disease that seldom arises in an individual before the age of forty years, and is most frequent between the ages of forty and fifty. I have seen one case in a woman of but twenty-eight years. This case, like practically all cases of carcinoma occurring in the young, was extremely malignant; it was quite inoperable when first seen, and destroyed the life of the patient within three months after this, the total known duration of the disease having been less than seven months. Here and there we find reported in surgical literature instances of

cancer of the tongue in those less than twenty years of age, but these occurrences are so exceptional that a surgeon is justified in regarding a growth that appears well before the age of forty as in all probability nonmalignant. A growth that appears after the age of forty years is more probably malignant than innocent.

Causes.—The cause of cancer of the tongue, like that of cancer in any other part of the body, is a matter of great dispute. Some observers maintain that the condition is parasitic, and that the tongue is constantly, or at least frequently, exposed to the parasitic cause, whatever it may be; other observers hold that cancer of the tongue is due to chronic irritation. Still others would co-ordinate these two views by asserting that chronic irritation favors the entrance of the parasite. We do know beyond doubt that chronic irritations of the tongue are likely to be followed by carcinoma. Cases like the one reported by Dennis, of New York, strongly confirm this view. The man was a workman who made a custom of holding nails in his mouth. Just at the point where he held the nails his tongue became sore and a cancer developed. I have seen a case exactly similar to this one reported by Dennis. Every surgeon has seen instances of cancer arising at a point on the tongue that had been long irritated by a jagged tooth. Again, all surgeons are familiar with the fact that chronic inflammations of the tongue may eventuate in cancer, and that the repeated use of caustics on a nonmalignant ulcer or upon a papilloma may result in the development of cancer. The drinking of raw spirits is thought by some to be a probable causative irritation. The use of tobacco by chewing or by smoking does seem to be responsible for not a few cases. In discussing leukoplakia I have already dwelt upon the fact that, whereas the condition may arise in those that do not smoke, it is infinitely more common in those that do, and that an area of leukoplakia seems to have a special disposition to become carcinomatous. It is strange, however, that Whitehead, in 104 cases of cancer of the tongue, found that only 61 of these patients smoked.

When a person smokes a short-stemmed pipe which becomes hot, there seems to be no question that the tongue may be so irritated at the point where it habitually touches the stem of the pipe that cancer may arise, the irritation in such a case being due to the hot pipe-stem rather than to hot tobacco smoke. Kümmel [15] states that in a list of 159 cases of cancer the growth was preceded by distinct leukoplakia in 34.6 per cent., and that in 19.2 per cent. of the cases of cancer there were at least a few white patches present, making over 50 per cent. of cases in which white patches or distinct leukoplakia were predecessors of carcinoma.

There seems to be no question that any form of chronic ulcer of the tongue may become carcinomatous, and that an innocent epithelial growth of the tongue—for instance, an adenoma or a papilloma—may become cancerous. Personally, I am convinced from clinical observation that chronic irritation is the most influential factor—although, perhaps, not the sole factor—in causing cancer of the tongue.

The Precancerous Stage.—If an area upon the tongue exhibits only inflammatory changes and is not yet cancerous, although it is evolving gradually and inexorably into carcinoma, we call the condition the precancerous stage of cancer. This term, like so much else that is valuable in this branch of surgery, we owe to Butlin. This term is valuable because it makes clear what must be the inevitable result of neglecting certain conditions, and also because it points the way with emphasis to the proper treatment of such conditions. Jacobson [16] has dwelt with great force on the value of the designation.

Butlin believes that a wart or a warty growth will certainly become cancerous if not removed, and is, therefore, much more surely a precancerous condition than is an ulcer, a nodule, or an area of chronic inflammation. Exactly when a precancerous condition becomes cancerous cannot be recognized clinically. When the surgeon is able to recognize the condition as cancer it has probably been cancerous for some time. One should suspect that an ulcer is in a precancerous stage when it persists, in spite of the removal of the cause and in spite of proper treatment, when the patient is forty years or more of age, and when there is no marked induration or fixation of the sore. A short time since Butlin [17] announced his belief that many, if not most of the supposed precancerous conditions, are cancerous rather than precancerous. He has proved this by removing areas thought to be precancerous and finding by microscopic study that they are unquestionably cancerous. He says that he is "now wondering if there are really any conditions perceptible to human sight and feel which are precancerous in the sense in which" he has "been accustomed to employ the term."

I have spoken of the value of the term precancerous. Butlin's recent remarks show the danger of it. If a condition is regarded as precancerous, one is justified in merely removing the growth and a portion of the tongue about it; but if it is believed to be actual cancer, even though this fact is not clinically demonstrable, one must do more than remove the growth from the tongue—one must also clear out the glands from the neck.

Origin and Development.—Cancer of the tongue may begin in several different ways. A chronic ulcer may take on induration at the margin and evolve into a typical carcinoma, a nodular area may break into ulceration, a vesicle may rupture, a papule may ulcerate, a fissure may form in an area of chronic inflammation, a papilloma may indurate and take on carcinomatous changes, or the cancer may appear originally as an ulceration. A warty growth is certain to become carcinomatous early.

Carcinomata of the tongue spring, practically invariably, from the squamous epithelium and almost never from the glandular epithelium. When one reflects on the large number of mucous glands in the tongue it seems strange that glandular carcinoma should not be more frequent. It is true that Steiner has reported a case of cylindric-cell carcinoma of the tongue, but this is an exception so distinct as to be almost a surgical curiosity. Most surgeons believe that the carcinomata that

originally present themselves as nodules beneath the mucous membrane must be of the glandular variety, but Butlin says that a vast majority even of these cases arise from the squamous cells, and that in them carcinomatous mass grows inward.

When a carcinoma of the tongue has fully developed it may be found in one of these forms. The commonest form is that of a foul, irregular ulcer, with an uneven and sloughy floor, and with rolled-out, knobby, and hardened edges. Around this ulcer there is invariably an extensive area of dense induration. The other form of growth is known as a warty or papillary carcinoma. It is found as a warty surface which is fissured here and there, and is surrounded by an area of induration. A form of growth occasionally encountered is characterized by the presence of an

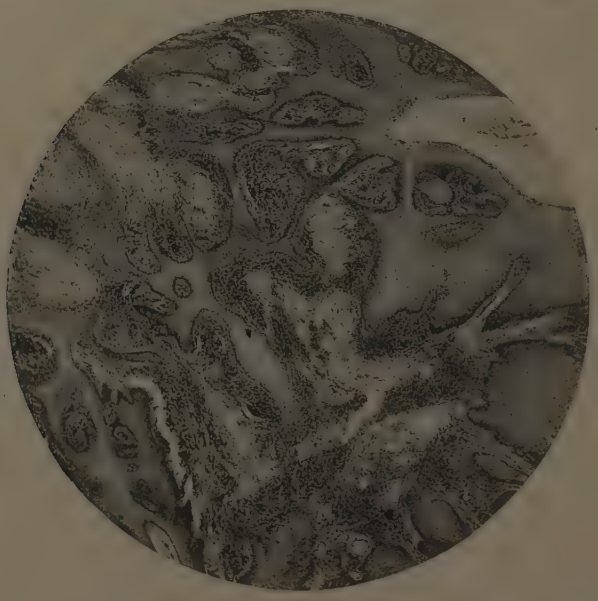

FIG. 375.—LEUKOPLAKIA LINGUÆ, SHOWING DOWNGROWTH OF RETE. (M. B. Hartzell.)

excessive amount of fibrous tissue, and in this condition the ulcer may be very small and the induration very extensive. In such a carcinoma extension is comparatively slow.

Lymphatic Infection.—The lymph-glands are involved very early in carcinoma of the tongue—how early is a matter of some uncertainty. On two occasions I have removed a carcinoma of the tongue within three months after it had first been noticed that the tongue was sore. In each case I cleared out the anterior triangle of the corresponding side of the neck, although I could detect no enlarged glands, and in each case the pathologist reported to me that there was beginning carcinoma in the glands that had been removed. It is imperative in every well-established case of carcinoma of the tongue, however limited it may be, to regard the glands as infected at the moment that the case is first seen.

The early involvement of glands indicates the virulently malignant character of carcinoma of the tongue. It is an interesting fact, however, that, whereas the adjacent lymph-glands are early and certainly involved, there is seldom metastasis to distant parts. The growth in the vast majority of cases remains a growth of the tongue and the adjacent parts, and of the associated lymph-glands. Which particular lymph-glands become involved, and in what order, has been the subject of considerable dispute. There is one thing that we do know with certainty, and that is that the glands are infected long before they are palpably enlarged; and there is another thing that we know with equal certainty—that the old idea that many enlargements of the glands in cases of carcinoma of the tongue are merely inflammatory is an absolute and often a ghastly

FIG. 376.—CARCINOMA LINGUÆ POST LEUKOPLAKIAM. (M. B. Hartzell.)

error. It is true that inflammatory enlargement may occur, owing to putridity within the mouth or to the absorption of pyogenic bacteria, but even when inflammatory enlargement does occur the glands are practically certain to be carcinomatous, as well as inflamed, because inflammatory enlargement of the glands only takes place in well-developed cases of cancer.

As to the glands are first diseased, Butlin says that, roughly speaking, a cancer of the tip of the tongue will first of all involve the submental glands; that a cancer of the middle of the tongue and the floor of the mouth will first involve the submental, the submaxillary, and the parotid glands; and that a cancer of the base of the tongue will first involve the upper group and the lower group of the deep cervical glands. He adds that, as a matter of fact, however, this rough division fails of

accuracy in a large number of cases, and it is the part of wisdom that the surgeon should regard the deep cervical glands as infected in all cases. The submental, the submaxillary, and the superior parotid glands drain into the deep cervical glands, and both systems ought to be removed in cancer of the tongue.

Edmund Owen,[18] makes the following impressive and important statement: "But there is an unhappy feature in the lymphatics of the tongue which is apt to spoil the best-laid surgical plans. It is that they do not observe that anatomic precision which nerves, arteries, and even veins are accustomed to follow, but, passing irregularly across the median plane, may bring infection to the glands on both sides of the neck, while the lingual ulcer, perhaps still small, remains one-sided." In other words, one cannot map out upon the tongue a certain area and affirm that it corresponds certainly with a definite group of lymph-glands, and one cannot even affirm that the glandular infection is limited to the same side of the neck as the side on which the tongue is affected. Some years ago Kuttner was so well convinced of this fact that he recommended removing the lymphatics from both sides of the neck in every surgical operation for cancer of the tongue. If the anterior two-thirds of the tongue is diseased the lymphatic involvement is liable for some time to be one-sided, although, if the patient lives for a year or more, the other side is almost certain to be infected. If the posterior portion of the tongue, however, is cancerous, both sides of the neck are sure to be involved, because the lymphatics of the posterior third seem to pass freely across the median line.

This disposition to involve the other half of the neck was strikingly exhibited in a patient that I recently showed before the clinic in the Jefferson Hospital. He had been operated upon one year before. A considerable portion of the tongue had been removed for a cancer of the right side of the anterior portion of this organ. The glands beneath the jaw and along the great vessels of the right side of the neck had been carefully removed in the manner advised by Butlin. When I again showed the patient to the clinic there was not a trace of recurrence in the stump of the tongue, not a sign of regrowth on the side of the neck operated upon, but there was a mass of inoperable carcinomatous glands on the opposite side.

Signs and Symptoms.—The appearance of the growth in the beginning and its appearance when well developed have been set forth in a previous paragraph. A very few cases are free from pain, but, as a rule, the condition is a very painful one, and in many cases is torturing. If the growth is toward the base of the tongue, pain is felt in the ears as well as in the tongue itself. The organ is stiff and attempts to move it are painful. The taking of any irritating article of food or drink causes severe pain. Articulation is muffled and indistinct and efforts at talking are productive of suffering. Sooner or later, in most cases, there is a great hypersecretion of mucus and saliva, which come to dribble constantly from the mouth. The breath and the dribbling saliva become foul and frequently horribly offensive. In a number of

cases as the growth spreads the sufferer becomes unable to open his mouth—except, perhaps, a little. In some cases he is entirely unable to separate the teeth. Swallowing is always a difficult matter, because the tongue is so immobile and painful that it cannot be turned backward to propel the food into the pharynx.

A growth of the front part of the tongue as it spreads passes to the floor of the mouth and the body of the inferior maxillary bone. A growth of the back of the tongue, as it spreads, passes to the soft palate, the pillars of the fauces, the tonsils, the pharynx, and the epiglottis. In a great many cases sloughing of the cancerous tissue occurs, and such sloughing may be responsible for the production of serious, desperate, or even fatal hemorrhage. The enlarged glands may ultimately soften and break down, huge raw and sloughing surfaces being exposed. From these surfaces serious or fatal bleeding may occur.

The constant swallowing of putrid matter is apt to induce gastro-intestinal disturbances. Bronchopneumonia from sepsis is by no means uncommon.

A person with cancer of the tongue, if not operated upon, will almost inevitably die within two years, and in many cases within one year. I have already cited a case in a patient who died within seven months of the onset of the growth. Death may be due to a violent hemorrhage or to repeated hemorrhages from the tongue or from broken-down carcinomatous regions in the neck, to exhaustion, to sepsis, to gastro-intestinal disturbance, or to septic pneumonia. Metastases occasionally, though seldom, take place, and even when they do, they are not usually the responsible cause of death, which in these cases occurs before the metastases have time to kill.

The reason why lingual carcinoma spreads so rapidly has been pointed out by Heidenhain, of Greifswald. The lingnal muscles contract almost constantly and so force carcinoma cells into healthy areas.

Wölfler has described a very rare form of carcinoma which grows very slowly and may actually remain latent for years.

Diagnosis.—Early diagnosis is of the very first importance. Cancer of the tongue is at first a strictly local and curable disease, but every week of delay in applying the proper radical treatment increases the chance of dissemination into adjacent structures and into the lymph-glands of the neck and lessens the chance of a positive cure. It is difficult—in fact, often impossible—to definitely identify as cancer very early cases of the disease, and any doubtful area should be removed and examined by a capable microscopist. If it then appears that the condition is cancerous the glands of the neck should be removed.

As previously stated, syphilitic conditions may be confused with carcinoma. The differential diagnosis has been discussed under the heading of Syphilis of the Tongue. If, in spite of the most careful study, the diagnosis still remains uncertain, and if the therapeutic test has failed to produce rapid results, a portion of the edge of the ulcer and of the adjacent apparently healthy tongue should be removed for microscopic study. The diagnosis between carcinoma and tuberculosis of

the tongue has been considered under the head of Tuberculosis of the Tongue.

I have spoken of the fact that warty growths become cancerous extremely early. Exactly when this change begins is doubtful. When the area ulcerates and indurates it has certainly begun, although it is quite evident that the process must have started before the carcinomatous change is manifest to the surgeon. It is, therefore, wiser to regard warty growths as cancerous from the very beginning. It is impossible, also, to tell exactly when a simple ulcer becomes cancerous. The change starts at the edge, which begins to indurate. The induration becomes harder and of greater width. These changes are especially significant if the individual be forty years of age or over. It is extremely difficult to tell when a fissure becomes cancerous, and in examining it its edges should be lifted freely apart; otherwise no real view of the condition can be obtained. Owing to the uncertainty as to fissures, it is wise to excise them and make a microscopic examination of the tissue removed.

Prognosis.—I have already spoken of the fact that cancer, if unoperated upon, is a disease that is certainly fatal within two years. It is usually fatal within eighteen months. The only exception to this statement is in that very rare form of carcinoma described by Wölfler, which seems to have periods of distinct latency.

Treatment.—All cases of carcinoma of the tongue must be divided into three great groups: (1) those in which an operation offers some chance of cure; (2) those in which an operation offers no chance of cure, but does offer a chance of palliating the disease and prolonging life; and (3) those in which any operation is entirely out of the question. In cases advanced in exhaustion and in sepsis in which there are huge masses of carcinomatous glands in the neck, and in which, perhaps, the jaw, the palate, the pharynx, and the epiglottis are involved, it is perfectly useless to undertake any operation except possibly a tracheotomy, to prevent suffocation.

There is, however, a large group of cases in which it is impossible to cure the patient, but in which something may be done to contribute to his comfort. As Jacobson [19] says: "Death by recurrence in the glands of the neck is much less painful and dreadful than death by cancer in the mouth." Therefore, in a number of advanced cases one is justified in removing the tongue and clearing out the glands from the neck, even if they are very positively enlarged. There is no hope of curing the patient if the glands have begun to soften, and there is practically none if the glands under the upper end of the sternocleidomastoid muscle, adjacent to the mastoid process and passing into the base of the skull, are seriously diseased, but even in these cases the removal of the tongue itself may mitigate the pain and the horrible foulness, and may prevent slow death from starvation.

If it is decided that there is some chance to cure the disease a radical operation should be attempted. Some surgeons have maintained that a radical operation, no matter how small the cancer, should consist in removing the entire tongue. I do not believe in this contention. It is

the experience of all surgeons that have done many of these operations that when a part of the tongue or one side of that organ has been removed for carcinoma, recurrence in the stump is not common. Growth in the neck or regrowth in the neck is exceedingly common, but regrowth in the stump of the tongue is comparatively seldom encountered. Then, again, the stump of the tongue, even when small, is very useful. It aids swallowing, facilitates articulation, and prevents the constant dribbling of saliva.

If the growth in the tongue is small and limited one should follow Butlin's advice and remove the growth, taking with it on all sides at least ¾ inch of apparently healthy tissue. If the growth is limited to the tip of the tongue it may be removed by a V-shaped incision. If there is a considerable growth on the side of the front part of the tongue that half of the tongue should be removed. If there is a considerable growth involving both sides of the anterior portion of the tongue all of the anterior portion should be removed; that is, the entire front of the tongue should be cut away. This rule should be followed whenever the growth crosses the middle line. If the growth is at the base of the tongue, even if it is on one side, the entire tongue should be removed, for it is practically certain that the opposite half will be quickly infected. Additional and very formidable operative procedures are necessary if the floor of the mouth is involved, if the jaw-bone has been attacked, and if the pharynx or the soft palate is diseased.

The surgeon must regard the glands as infected in every case, no matter how early the patient is seen. This is the only possible course for safety. The general rule has been to clear out radically the glands on the corresponding side of the neck. In a previous portion of this article I have already stated my belief that the glands on the opposite side of the neck are also liable to be infected, and are certain to be so if the base of the tongue is cancerous. I believe that it would be the line of the greatest safety to clear out both sides of the neck, even if this has to be done in two operations, and certainly if cancer infects the base of the tongue it should be insisted upon. In my last 6 cases I have recommended this procedure. One of the patients declined it and the other 5 accepted it.

We owe our knowledge of the necessity for clearing out the glands of one side of the neck more to Butlin than to any other surgeon. His labors in this respect have been fruitful of good and his influence has been broadly felt throughout the world. He, however, does not recommend clearing out both sides of the neck.

In all these operations there comes up the question whether we shall clear out the glands and remove the tongue at one seance or make these two operations separate and separated procedures. In most cases in which glandular involvement is trivial or is not detectible by palpation, the tongue should be removed first and the glands within a week or so. Butlin waits, as a rule, about nine days after removing the tongue before he removes the glands. W. Watson Cheyne[20] has pointed out that the removal of the glands *with* the tongue, if White-

head's operation has been performed, increases the shock and the danger of death. I agree with Cheyne that if the glandular involvement is marked the growth in the glands will be much more rapid than will the growth in the tongue. In such a case the diseased glands should be removed before the tongue, because if the tongue is removed first and the surgeon has to wait a week before operating on the glands, the glandular mass may become inoperable before he is ready to attack it surgically. Therefore, in all advanced cases the lymphatics should be cleared out before the tongue is removed. The latter operation should be done after the wound in the neck has healed. If the disease in the tongue is very far advanced and the disease in the neck is far advanced also, operation having been decided upon, both operations may be done in one seance.

Butlin [21] has described with great clearness the method of procedure that he advocates inremoving the glands. This operation is by no means free from danger. He has had 4 deaths in 28 cases. He points out, however, that in 3 of the cases that terminated fatally he had removed the tongue and cleared out the glands at one operation. Now that he has separated these two procedures, the mortality has been lessened. He calls attention with great emphasis to the fact that enlargement is not the test of disease; that the glands are diseased long before they are enlarged.

Butlin leaves little more than skin in the flap, because, as he points out, there are certain very superficial lymphatic glands in the submaxillary salivary gland, and there are also superficial glands in the submental region. When the surgeon is removing the superior carotid glands he will inevitably wound the parotid gland. The various glands first involved in cancer of the tongue have already been mentioned—the submental, the submaxillary, and the superior carotid—and all these glands convey their lymph to the glands at the carotid bifurcation. In some cases it is the glands at the carotid bifurcation that first show enlargement. Butlin removes from the anterior triangle the lymph-glands, the submaxillary salivary gland, the fat, the connective tissue, the platysma myoides muscle, part of the omohyoid muscle, many veins (which sometimes include a part of the internal jugular vein), and occasionally a portion of the external carotid artery.

Personally, I believe that it is a great advantage in these cases to clear out the triangle in the manner suggested by Crile, of Cleveland: taking out the internal jugular vein with the contents of the triangle and keeping wide of all possible points of infection. Whatever method is followed the mass must be taken out in one piece.

H. L. Maitland [22] has given a careful description of the glands of the neck and has forcibly advocated a radical operation by a method of his own. He makes a curved incision from the point of the chin to the mastoid process and a second incision along the anterior border of the sterno-mastoid muscle, curving back along the clavicle. The flaps are dissected up, and care is taken that they consist of skin alone in the submental region, over the submaxillary gland, and along the upper portion of the

course of the external jugular vein. He then cleanly dissects the digastric triangle, beginning at the point of the chin and passing outward and upward, giving careful attention to the gap between the outer edge of the mylohyoid and hyoglossus muscles. He opens the anterior layer of the outer portion of the deep cervical fascia, which at this point forms a box for the submaxillary gland. He pulls the glands forward, ties, and divides the facial artery, "the common facial and the anterior division of the temporomaxillary veins having previously been tied and divided." He then completes the dissection of the digastric triangle by carrying the dissection over the body of the lower jaw, so as to remove the lowermost facial glands. He next clears out that part of the digastric triangle back of the stylomaxillary ligament and removes the lower portion of the parotid gland, taking his dissection deep enough to reach the deep parotid glands. He then begins the dissection of the anterior triangle from before backward, until he reaches the anterior border of the sternomastoid muscle, and then divides this muscle at the level of the omohyoid and turns its lower portion down. He now proceeds with the clearing out of the anterior and posterior triangles from below upward, taking all the fascia of the vessels and passing up underneath the parotid gland. He finishes by cutting the sternomastoid muscle off from its insertion along with the lifted-up contents of the triangles. By this procedure he has removed the entire deep descending chain of cervical glands. As a last step in the operation he removes the internal jugular vein. He says that if this is removed earlier a great deal of valuable time will be lost in arresting venous bleeding.

This operation differs specifically from Butlin's in the fact that the latter does not remove the sternomastoid as a routine procedure. Maitland is convinced that only by removing this muscle is it possible to satisfactorily reach and remove the deep cervical glands. He maintains that it is not always necessary to remove the internal jugular vein, as when the sternomastoid has been removed it is much easier to thoroughly clean the vein. Maitland further points out that the removal of the muscle produces singularly little disability, and that after it has been performed all head movements are carried out by the postrotators.

This is a very radical operation, and I believe it to be a most efficient one.

Removal of the Tongue.[22]—When it has been determined to remove the tongue it is well to prepare the patient for the procedure. The teeth should be put in the best possible condition and carious teeth should be removed. The teeth should be cleansed twice a day by the use of a tooth-brush and Castile soap, and the mouth should be rinsed at frequent intervals with a dilute solution of peroxid of hydrogen followed by a solution of boric acid. Furthermore, it is advisable on the morning of the operation to administer to the patient 10 cc. of antistreptococcic serum and to give to him, half an hour before the administration of the anesthetic, a hypodermic injection of $\frac{1}{4}$ gr. of morphin. The anesthetic must be administered by a skillful man.

Chloroform is more convenient than ether, but I believe ether is safer and always use it.

The question of preliminary laryngotomy will present itself to the surgeon. Personally, I have never performed it. I have found that by placing the patient in the Trendelenburg position the blood that flows into the mouth does not tend to pass into the air-passages. The performance of an additional operation is always objectionable, unless it is called for by strong reasons. Whitehead does not recommend preliminary laryngotomy. It should, however, be noted that a surgeon of the very large experience of Jacobson approves of this preliminary measure, with plugging of the back of the mouth. He advocates it because, when the fauces are plugged and the patient is obtaining air through the laryngotomy cannula, the surgeon can operate with much greater deliberation, must stop far less frequently to arrest hemorrhage, and can take his time in sponging the parts and examining them—procedures that are really essential in enabling him to keep wide of the disease. Jacobson[23] recommends preliminary laryngotomy with plugging of the fauces when Whitehead's operation is to be performed on certain cases. It should be employed (1) if the surgeon is doubtful as to his means of controlling hemorrhage; (2) when the growth has passed into the posterior third of the tongue; (3) when the floor of the mouth is involved (he does not think it necessary if a growth is limited to the anterior half of the tongue, unless that organ is fixed to the floor of the mouth); and (4) if the surgeon has not a very skillful anesthetist.

The Operation.—Operations for the removal of a portion of the tongue or of the entire organ may be divided into two groups: intra-oral or buccal operations, and submaxillary operations.

1. *The Intra-oral or Buccal Operation (Whitehead's Operation).*—An intra-oral operation may be partial; that is, a small portion of the tongue or half of that organ may be removed. It may be complete, the entire tongue being taken away. The patient must be so placed that the surgeon will have an excellent light, whether a partial or a complete operation is to be performed. If a preliminary laryngotomy has been done the patient should be propped up into a semi-erect position, but if there has been no such preliminary operation he should be placed in the Trendelenburg position.

Removal of Half the Tongue.—This is a very valuable operation in many cases. The result obtained is a stump in which there is little danger of recurrence, and which is of the greatest use in articulation and deglutition. Jacobson protests against removing half of the tongue in an ulcerating cancer, unless the ulceration is evidently superficial. He never depends upon removing half the tongue when the cancer is on the side of the posterior third of the tongue, but he thinks very highly of it in the warty carcinomata with superficial ulceration.

Some surgeons approve of ligating the lingual artery before removing the tongue, or a portion of it, from within the mouth. Treves[24] thinks very highly of this procedure. Jacobson does not regard it as at

all necessary. In my earlier cases I practised it, but I have become convinced that it occupies an unnecessary amount of time and is without sufficient compensating advantages. It undoubtedly renders the arterial hemorrhage very trivial and makes the intra-oral manipulations easier, but the hemorrhage can be quite satisfactorily controlled without this rather troublesome antecedent procedure.

When the surgeon is ready to operate upon the tongue a gag is placed in the patient's mouth on the side opposite to that occupied by the growth (Fig. 377). A piece of stout silk is passed through the tip of the tongue by means of a needle, and is used to pull the tongue out of the mouth. With a knife the tongue should be split along its middle line to a point well posterior to the growth. The diseased

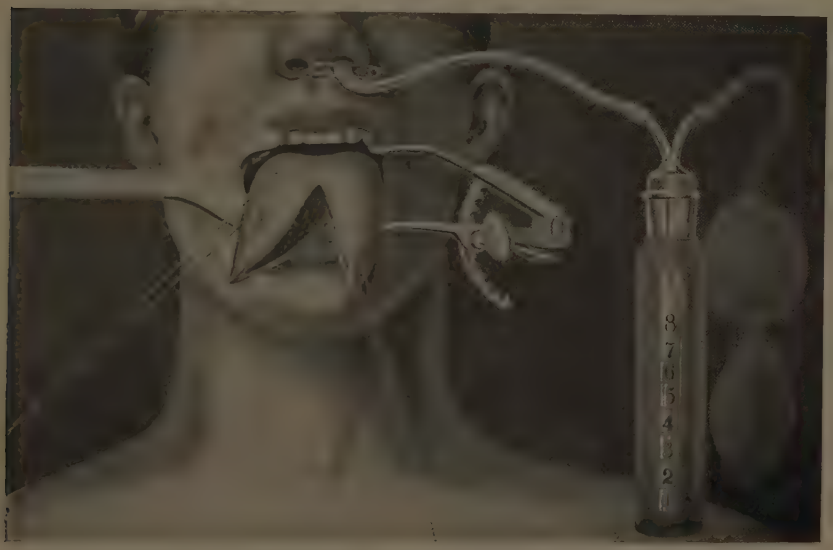

FIG. 377.—WHITEHEAD'S OPERATION FOR EXCISION OF ONE-HALF OF THE TONGUE. (Fowler.) Showing Junker's inhaler in use. The tube leading to the nose should be longer than that shown in the illustration.

portion is then grasped with a pair of tongue-forceps and the mucous membrane is cut with scissors between the tongue and the alveolar process of the lower jaw, the scissors being carried very close to the bone. Next, Jacobson advises that the anterior pillar of the fauces should be divided. He also makes what I have found to be a most excellent suggestion: that if the frenum is diseased several of the lower incisors should be pulled out in order that the scissors may properly reach the point desired.

Having freed the diseased half of the tongue, the next step is to divide the muscles that pass from the floor of the mouth into it. The diseased half of the tongue is then cut across transversely at the point desired. The diseased portion is removed and the linguals are caught and tied. The mucous membrane should be sutured over the stump with chromicized catgut.

Removal of the Whole Tongue from Within the Mouth (The Genuine Whitehead Operation).—This is conducted on exactly the same lines as the operation just described, the tongue being split along the middle line, one-half being first removed and then the other half. It is this operation that particularly bears the name of Whitehead. It should be borne in mind that the chief means of holding the tongue within the mouth are the frenum and the anterior pillars of the fauces, and these structures are divided with scissors and the reflected mucous membrane that runs from the tongue to the jaw is also divided. When any vessel is observed to bleed it is at once caught with the forceps. Whitehead simply twists it; many surgeons tie it. Whitehead states that the lingual arteries may usually be caught and clamped before dividing them. Before the tongue is cut across and removed a ligature should be passed through the glotto-epiglottidean fold. This ligature is kept in place for twenty-four hours, and if any respiratory difficulty occurs it is promptly relieved by pulling upon the ligature. Pulling upon the ligature will also serve to arrest oozing from the stump.

After the completion of the operation, Whitehead recommends washing the wound with an antiseptic solution and painting it with a varnish containing iodoform and turpentine.

Treatment of Case after Removal of Tongue.—In the after-treatment of such a case the patient must be gotten out of bed at the earliest possible moment. He should certainly sit up in bed the day after the operation and he may even be gotten up in a chair. If this is done the danger of septic pneumonia will be greatly lessened. He should be fed frequently by the mouth and should have liquid food given him. After each feeding the mouth should be cleansed with boric-acid solution. Whitehead reported that he had performed 101 of these operations with 3 deaths in uncomplicated cases.

Submaxillary Operations.—There are several different forms of these operations. One that is largely used is known as Kocher's method (Fig. 378), although Kocher himself now seldom employs it. We follow Binnie's[25] description. The patient is put in the Trendelenburg position and a stout traction thread is passed through the tongue. An incision is made below the symphysis menti and is carried downward to just above the hyoid bone. It is then carried outward to the anterior margin of the sternocleidomastoid muscle, and next carried up along the margin of this muscle to the level of the lobe of the ear. The flap of skin is lifted upward, and all the enlarged glands under the upper portion of the sternocleidomastoid muscle and beneath the lower jaw are removed. The anterior margin of the muscle is raised and the glands from beneath it are removed. "If the cancer affects the floor of the mouth, the fauces, or the jaw, it is wise to ligate the facial vein and the external carotid artery." The anterior belly of the digastric muscle should then be well exposed and the veins beneath it should be tied. Binnie advises that the glands that are exposed should be dissected freely until all the posterior belly of the digastric and all

of the stylohyoid muscle lie perfectly free in the posterior and inferior part of the wound. The lymphatic and salivary glands are then separated from the lower jaw. The same surgeon then directs that the insertion of the hyoglossus muscle at the posterior end of the great horn of the hyoid bone should be divided. This exposes the lingual artery, which is then to be tied. The mouth is opened into at the posteror margin of the mylohyoid muscle. The lingual muscle is cut off at the hyoid bone and all infiltrated tissue is removed. The tongue is then pulled out of the wound in the neck and cut across (Fig. 379). A large drainage-tube is carried through the neck wound into the mouth and gauze is inserted in the wound.

FIG. 378.—INCISION FOR EXCISION OF TONGUE THROUGH THE NECK, TOGETHER WITH THE LIGATION OF FACIAL AND LINGUAL ARTERIES, AND REMOVAL OF GLANDULAR TISSUE (KOCHER'S OPERATION). (Bickham.)

Sédillot's Operation.—It is this operation that is now preferred by Kocher.[26] It consists in dividing the lower lip in the median line and incising the skin beneath the chin down to the hyoid bone. The lower jaw is then sawn through in the median line and the two halves of the bone are widely separated by traction. The geniohyoid and genioglossus muscles are divided and wide exposure of the whole area of disease is afforded. The tongue is thus readily removed. The halves of the sawn jaw-bone are wired together.

The Value of Different Operations.—In weighing up the advantages of these operations it is evident that Sédillot's operation affords the most easy access, but that it is not a suitable one for removing the glands of the neck at one sitting. It leaves a dreadful cavity which will surely become infected if the neck is widely opened, and such infection may prove fatal. Another objection to it is that, though the two halves of the jaw are subsequently wired together, nonunion is by no means infrequent. Kocher's operation affords ready access to the

tongue, enables the surgeon to limit hemorrhage by tying the lingual on one side, and lets him remove the glands of the side of the neck on which the incision is placed. It leaves a large wound which inevitably becomes infected and must be drained by carrying a tube into the mouth and putting gauze into the wound. Taking everything into consideration, I believe the operation that is best suited for the majority of cases that are not too far advanced is the one advocated by Butlin;

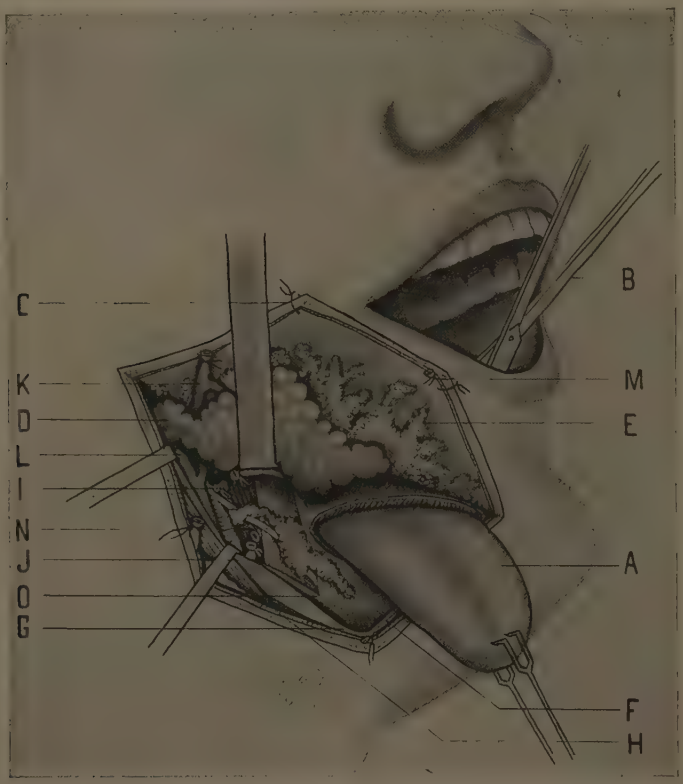

FIG. 379.—KOCHER'S EXCISION OF THE TONGUE THROUGH AN INCISION IN THE NECK. (Bickham.)

A, Tongue drawn through incision in mylohyoid muscle; B, scissors introduced through mouth, cutting base of tongue away from hyoid bone and its remaining attachments; C, flap raised from neck and stitched to cheek; D, submaxillary gland being dissected out; E, lymphatic glands and connective tissue being dissected out; F, anterior belly of digastric; G, posterior belly of digastric; H, sternomastoid muscle; I, facial artery ligated near origin from external carotid; J, lingual artery ligated near origin; K, external jugular vein ligated; L, internal jugular vein and communicating branch with facial; M, anterior jugular vein; N, hypoglossal nerve crossing hyoglossus muscle; O, ranine vein.

that is, the removal of the tongue by an intra-oral operation, and, nine or ten days afterward, the removal of the glands from the side of the neck corresponding to the side of the tongue that is diseased. Personally, I would advocate in some cases, and probably in many, the performance of a third operation a few days later for the clearing out of the glands from the opposite side of the neck. Of course, if a cancer affects the floor of the mouth or the jaw-bone some additional and formidable operative procedures are necessary.

Mortality from Operations.—The mortality of these operations must, of course, vary with the condition of the patient and the magnitude of the operation that is necessary. Whitehead reports 101 operations with 3 deaths in uncomplicated cases, but in complicated cases he had 17 deaths in 38 cases. As Butlin points out, Whitehead, in the aggregate, had 20 deaths in 139 operations—a little over 14 per cent. Butlin estimates, in cases of all magnitudes, that the mortality is in the neighborhood of 12½ per cent., that in uncomplicated operations it is scarcely above 7 per cent., that in operations carried out below the jaw it is over 20 per cent., and that if part of the jaw is removed it is over 25 per cent. The mortality has certainly been distinctly reduced within recent years.

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CHAPTER XLV.

TECHNIC OF ABDOMINAL SURGERY.

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GENERAL CONSIDERATIONS.

With the extraordinary advances that have been made in dealing with injuries and diseases of the abdominal cavity, and its neighboring organs, immature operators lose sight of the fact that every case which requires an opening through the peritoneal lining is at once a case of major surgery; occasionally, when least expected, a case of grave surgery.

The most careful tests and examinations often fail to disclose the serious conditions with which the surgeon is called upon to deal. Hence, the operator who undertakes this type of surgery must be reasonably capable of successfully meeting any of the complex problems incident to such a complex cavity. He must recognize normal as well as abnormal organic conditions. He must be prepared to carry to its completion any of the rare technical procedures that are called for by rare combinations of pathologic conditions. His judgment must not lead him into the undertaking of impossible or injudicious operations. He must, in other words, be able to withhold as well as to use his knife. Even the most skilled are deceived in their estimate of benign or malignant growths, and in the valuation of a concealed injury. The abdominal surgeon must be trained in his tactile as well as his visual sense. The educated finger often gives as much practical information as the eye. This is true, also, in preliminary examinations, and the trained surgeon not infrequently bases his decision as to the time and location of operation upon this educated sense of touch.

Furthermore, the after-care of patients subjected to a laparotomy involves as much responsibility as the technical steps of the operation itself. Every experienced surgeon has seen serious sequelæ, or even death, as a result of irresponsible or faulty postoperative care.

The remote results of operation, even in emergencies, require as careful and intelligent consideration as does the technic of the operation itself. And yet, bearing in mind the possible drawbacks that arise from unskilled operating, from untrained after-care, and from unavoidable disasters, we cannot but realize the enormous, almost incalculable, benefit that has come with the modern advances in abdominal surgery, and we must look upon this branch of surgery as one of the most blessed means for accomplishing good that has been vouchsafed the human race.

The important anatomic facts that concern the abdominal surgeon may be briefly stated. Where possible, motor nerves should not be sacrificed, and it is better to enter the abdomen with as little injury to the muscular bellies as possible. When muscular fibers must be cut transversely, the cut ends should be carefully approximated by suture at the close of operation.

Incisions that require rough handling of the wall or of the viscera, that necessitate prolonged and brutal retraction, are not justifiable on the score of the operator's vanity or of the cosmetic after-effects. Short incisions, insufficient to allow satisfactory and gentle manipulation of the viscera, as well as needlessly long wounds, are to be equally condemned. Except for diagnostic exploration in suspected malignant disease, an opening 1½ to 3 inches in length meets the ordinary surgical requirements better than an opening ½ inch in length and is just as capable of healing. On the other hand, long, gaping wounds in order to accommodate a clumsy hand or an indifferent conscience, especially when valuable motor nerves are sacrificed, are equally to be condemned. In brief, simplicity and directness in opening the abdomen is of equal importance with simplicity and directness in closing it. Any methods which depart from these fundamental principles must be looked at askance.

The various incisions for obtaining access to the different organs will be considered in detail below.

As regards topographic bounds of the abdomen, the classic division into epigastric, hypochondriac, umbilical, iliac, lumbar, and hypogastric, although empirical, still remains the most convenient and intelligible. The general arrangement of the viscera with relation to these areas in typical cases, as shown in detail in modern anatomies, is too well known to need repetition here; but it must ever be borne in mind that the surgeon is much more liable to encounter atypical than typical positions of the viscera. The diagnostician should also realize that the dissecting-room conception of visceral boundaries is very misleading when applied to the living normal or pathologic abdomen. Operation reveals most extraordinary discrepancies in the exact situation of organs as interpreted to us by percussion.

PREPARATION OF PATIENT.

The preparation of patients for operation in general will be considered in the chapter on Operative Surgery. Granted that the surgical risk, as regards the functions of the heart, the lungs, and the kidneys, has been estimated, we can materially lessen the operative dangers in abdominal surgery by a proper treatment of the gastro-intestinal tract. Fecal masses and decomposing material in the intestines augment the surgical dangers by the accumulation of gases and by the absorption of toxins formed within the canal. Both are fostered by diminution of peristalsis and by lessened rectal excretion. If we add the physical and mental depression that attends a postoperative nausea it is not

difficult to see why progress in improperly prepared patients may be tedious or even alarming. Elaborate preliminary preparation, on the other hand, defeats its own object. Long and careful dieting, with repeated catharsis, lessens the functional capabilities of the digestive tract. This is still further impaired by the mental worry and anticipation that attends a preparation extending over several days. So that, other things being equal, we believe that continuation of the customary diet up to a brisk, vigorous catharsis, and confinement in bed less than twenty-four hours before operation, is sufficient to put a patient in the best condition for the majority of abdominal operations. With this in view, a patient is allowed his customary diet up to the evening before operation, when he is given 1½ to 2 oz. of castor oil, which sweeps the intestines free of all foreign material and leaves practically nothing for fermentation. In patients thus prepared the ease in handling the viscera at operation is increased to a remarkable extent. Where there is a likelihood of extensive gastric or upper intestinal operations, local septic conditions may be practically eliminated by a diet of sterile food for several days, and repeated gastric lavage. Otherwise, the simple method given above is sufficient.

When possible, a patient is given a tub bath the evening before operation. The abdomen is widely shaved at this time or on the operating-table, and he is allowed to pass the night without the discomfort of a wet antiseptic dressing. These dressings are not only a source of discomfort and annoyance, but they irritate the skin, contributing, if anything, against a sterile field.

Especial emphasis is given to cleansing the umbilicus which is always much dirtier than the surrounding skin. It may be isolated with a collodion seal, or excised as a preliminary step in the operation. The latter is rarely necessary, and may be seriously objected to on account of needless disfigurement.

To combat the thirst that comes after all abdominal operations, patients may be directed to drink freely of water for a period of several days beforehand.

Except in marked cardiac lesions or in advanced renal disease, there is little routine drug treatment that is worthy of consideration. Irregular hearts may be steadied by some of the cardiac tonics, morphin or bromids, rest, judicious feeding, etc., but as a routine such cardiac stimulants as strychnin, alcohol, digitalis, etc., are rarely indicated.

Morphin and atropin given shortly before operation control the excessive bronchial and faucial secretions and augment the effects of the anesthetic. Their use is attended by less postoperative pain, and from clinical evidence the postoperative ether vomiting is lessened, although in this respect so much depends upon the anesthetizer, the mental makeup of the patient, and the technic of the operation, that it is difficult to accord a just amount of benefit to the drug employed.

In advanced cardiac and renal lesions, and even in the acute pulmonary inflammations, special drug administration beyond that which the condition of the patient ordinarily would call for, is not indicated.

In operating on a patient with any of these contra-indications, more depends upon the anesthetizer and the skill of the surgeon than upon any drugs for a successful outcome. It is doubtful if there are patients with any cardiac, renal, or even pulmonary lesion who cannot be carried safely through a short etherization, provided the prospective relief by surgical intervention is great enough to warrant operation.

Mental equilibrium is important. Calmness on the part of the surgeon and his subordinates, quiet, undisturbing surroundings, especially during anesthetization, avoidance of disagreeable technical shocks, etc., are all important.

FIG. 380.—TRENDELENBURG POSITION
Note the two means of preventing the patient from slipping, either one of which may be used: 1. The braces to the shoulder. 2. The flexed legs held by a bandage.

Bodily warmth must be maintained throughout an operation, especially in the very young and very old. This is secured by warm, ventilated operating-rooms free from draughts; by the protection of the body from rapid evaporation after irrigation or from the use of wet towels or sheets. Tables that can be artificially warmed by hot water or electrically heated mattresses, etc., are of value in prolonged operations on the anemic, on those with advanced malignant disease, or on infants and elderly people. If possible, infants should always be kept warm artificially during operation. Woolen stockings, woolen suits or wraps, and the so-called pneumonia jackets, especially in old people, are indispensable. Equally important is it to maintain the bodily warmth for the few hours after operation, when there is shock, sweating,

and general relaxation. Especial care should be taken against the sudden chill that follows evaporation from an exposed arm, shoulder, or chest at this period.

The head-down, or so-called *Trendelenburg's position*, is most valuable for securing access to the lower abdomen, unhampered by the intestines. In septic operations the upper half of the abdomen must be carefully protected from infection, owing to the greater absorptive powers of the diaphragmatic lymphatics. Its use in plethoric patients with flabby hearts entails risk, and in any case it is best to return the patient not too suddenly to the horizontal position, because of the resulting cerebral anemia.

In existing septic peritonitis, as we shall see in a later chapter, the use of the *pelvis-low* (*Fowler*) *position* is of great value, before, during, and after operation, as it limits the contact of septic material to the lower surfaces of the peritoneum, from which absorption is much less active than from the diaphragmatic region. This may be secured by elevating the head of the bed or table for eighteen inches or by placing the patient more or less upright.

INCISIONS.

The performance of a laparotomy varies in many of its details according to the training and experience of the individual surgeon. The main principles that should govern the operator are to open the layers *seriatim*, to start preferably with a small exploratory opening, and to recognize each layer accurately, especially the properitoneal fat and the peritoneum. The last precaution applies to cases with a distended bladder, with parietal tumors or infection, or with intra-abdominal infections and adhesions. The prevesical fascia and fat should not be easily mistaken; the fat is granular and in the median line is characterized by transverse vessels which are seen in the properitoneal fat elsewhere to a slight degree only. To recognize adherent viscera or pathologic growths is often most difficult, and it may be wise to make a distant button-hole incision in a part of the abdomen that is presumably normal, in order to locate definitely the inner peritoneal surface. I have long ceased the routine practice of preliminary catheterization of patients. A bladder containing a few ounces of urine is its own safest landmark, and may be of great assistance in some obscure pelvic operations. For general purposes the median incision above or below the umbilicus is the most useful. There is least damage to motor nerves, no muscles are severed transversely, and practically all the organs can be attacked with more or less ease through the thinnest portion of the wall. If the wound is carefully sutured there is very small danger of postoperative hernia. Except in cases of exploration for diagnosis, however, it is a good rule to open the abdomen approximately over the organ or organs involved. Furthermore, any incision by which the aponeurotic opening is protected by a substantial mass of muscular tissue at the conclusion of an operation is rarely the seat

of a hernia. The skin itself is no protection against hernia, and should never be considered on this basis.

Instead of making the incision directly in the median line, it may be carried about one-half inch to the right or the left, the rectus being retracted outward or split lengthwise, preferably the former. In this way a solid muscular belly is interposed between the sheath openings at the time of closure of the wound. This may be modified by employing a median incision through the skin and lateral incisions through the muscular sheath. Because of the sacrifice of motor nerves incisions through the linea semilunaris are less to be recommended than those through the linea alba or over some of the protecting muscles. To gain access to the lateral portions of the cavity we may employ the so-called *gridiron* or *McBurney incision*, or some form that depends upon the protection of the rectus against subsequent hernia. In the typical gridiron incision the skin is opened parallel with the fibers of the external oblique, which are separated and retracted; the internal oblique and transversalis fibers are each split in line with their course and retracted. The peritoneum is opened in whatever direction suits the operator. This may give too small an opening at times, when it will be necessary to cut across the internal oblique inward to the rectus, the sheath of which may be opened lengthwise and the muscle retracted.

One of the most useful incisions, especially in operations in the region of the appendix, is that which opens the anterior sheath of the rectus about half an inch to the inner side of the semilunar line. The muscular belly is then retracted inward, the underlying thin layer of fat, with its loose nerves, is easily pushed upward and downward, and the posterior sheath and peritoneum opened in the same line as that in the anterior sheath. The rectus may be split if preferred, but it frequently entails much troublesome bleeding and the nerves are more easily injured. In the upper rectus when opening the abdomen for operating on the bile passages, stomach, or intestines, it is customary to split the muscle. If more room is needed an ample opening is secured by making an oblique incision at the upper or lower end, as suggested by Bevan, that at the upper passing inward along the costal border, that at the lower passing obliquely outward.

Incisions that involve destruction of the attachments of muscles to bones, as for instance, along the iliac crest, have little to recommend them except occasional necessity.

A very useful *incision for operations on the kidney and upper ureter* is that which extends obliquely upward and outward from the semilunar line, splitting the external oblique, sacrificing relatively few fibers of the internal oblique, which are sutured later, and splitting the transversalis. The peritoneal cavity may or may not be opened, as required, while a most satisfactory opportunity is given to expose, handle, and otherwise operate upon the kidney. The ureter is easily exposed as far as the pelvic brim. To expose the deeper pelvic portion we can use an oblique incision in the groin, gaining access to the lateral part of the pelvis by pushing the peritoneum inward. In the loin we may

reach the kidney through an incision either along the outer edge of the erector spinæ muscles, or passing obliquely from the twelfth rib close to the iliac crest, but far enough away to allow muscular flaps for suture.

Incisions made along the natural lines of cleavage for the purpose of concealment or to prevent late widening of the scar, are justifiable only when these angles do not conflict with the more important line of incision of the deeper structures. Thus, the suprapubic transverse incision employed in operations on the pelvic viscera has nothing to commend it beyond its cosmetic results. Careful suture of the subcutaneous fascia will minimize the tendency to postoperative widening of the scar. As long ago as 1880, Packard showed that by cutting through the skin in a slanting direction the scar can be reduced to such an extent that it is practically invisible. It requires the use of special knives and most painstaking adjustment of the edges on completion of the operation.

When an operation is limited to a single organ, such as the appendix, gall-bladder, stomach, uterus, etc., a short local incision suffices. If the field of operation is unexpectedly carried into a neighboring region, requiring an inordinately long incision, it is better if possible, to make a second, separate opening rather than to extend the first incision at the expense of important motor nerves, evisceration, and unnecessary shock. Thus, in order to attack the bile passages at the time of operation on the appendix, a second opening may be made through the upper rectus. This is preferable to extending the primary opening through important nerves. The skin incision may be carried upward or downward if desired, but not that through the aponeurosis. In a similar way, it is better to make two lateral openings than to forcibly retract a single lateral opening in order to deal with some lesion on the opposite side of the abdomen. The marked increase of shock due to rough manipulation of the abdominal viscera has been well shown by Crile (Vol. I., p. 934).

Cross incisions are used by some surgeons in various localities. Those which cut across the rectus have little to recommend them over the longitudinal incisions, even though suture of the severed muscles is rarely followed by hernia. No better exposure is obtained, and normal tissue is damaged only to be replaced by abnormal tissue. The transverse incision of Péan, passing laterally from the outer edge of the rectus to the sacrolumbalis necessarily damages more tissue than the oblique incision.

The transverse incision over the appendix, starting at the outer edge of the rectus at the level of the iliac spine and passing directly outward through the aponeurosis of the external oblique, but splitting the internal oblique and transversalis, is used in one or another modified form by Davis and others. It offers a good access to the cavity, and does not destroy motor nerves, but it seems doubtful if it has any advantages over the gridiron or the pre-rectus incision.

Oblique incisions below the costal arch are useful at times in operations on the gall-bladder, or splenic flexure, for gastrostomy, etc., but even

here muscle-splitting and nerve-shunning incisions are equally of value and are to be recommended in the great majority of cases. Occasionally the abdomen may be opened alongside the sacrum in operations about the rectum or prostate, or through the vaginal vault in either the anterior or posterior quadrant.

In re-opening an abdomen after a lapse of months or years, if there is no hernia, the incision may be made through the scar if it is a narrow one. If it is wide or unsightly it is best to dissect it away before penetrating the deeper layers. Care must be taken not to injure an adherent loop of intestine. Unless there has been a history of peritoneal infection at the preceding operation, it is rare to find the bowel adherent to the scar to any extent. In hernias that form in scars, the cicatricial covering is so thin that injury is easily inflicted upon the adherent bowel.

The *excision of the umbilicus* is systematically carried out by some surgeons, except in the case of young women. The difficulty in disinfection and in suturing after operation forms the basis for this measure. The reasons are good, but as a matter of practical experience infection seldom takes its origin from this source. In umbilical hernia it is well to disinfect the umbilicus with pure carbolic acid. In opening the abdomen at the level of the umbilicus the left side is chosen in order to avoid injury to the round ligament. The choice is not imperative, however.

Abdomens with fat walls are at times most difficult and trying to deal with. In such cases the subcutaneous fat lies in two distinct layers separated by the subcutaneous fascia. The blood-vessels are relatively few, and have very delicate walls. The wound quickly becomes filled with an oily liquid from the cut surfaces. Necrosis from trauma easily takes place, owing to the poor vascular supply, so that an infection that would readily be taken care of elsewhere will cause trouble in the after healing. The fat layer that lies between the fascia transversalis and the peritoneum varies in thickness in different regions. In the umbilical region it is practically wanting. In the uppermost and lowermost portions of the median line it is quite thick, even in thin patients. Beneath the rectus it is practically absent below the level of the navel, except in very fat patients. Higher up it is more in evidence. Where the properitoneal fat layer is very thin or wanting, the peritoneum is so closely fused with the fascia that it may be very difficult to dissect them apart. Incisions carried close to the symphysis open up the loose prevesical fascia, which is constantly changing its position with the conditions of the bladder. This is a favorite location for the collection of blood and for infection. Unless demanded by the existing conditions median incisions must not be carried too far upward alongside the xiphoid cartilage, for fear of opening a low-lying pleural cavity.

The peritoneum may be opened with a free hand, especially when it is fused with the fascia transversalis, or it may be caught up with forceps between which the incision is made. By pinching a fold of peritoneum between the thumb and finger, or by tucking the finger

beneath a transverse fold of peritoneum, underlying and non-adherent coils are forced away from the danger of being wounded. A short accidental scarification of one of the viscera needs no attention. A deep accidental wound is best closed at once with a fine suture. Penetrating wounds of the bladder or intestine demand careful invagination and suture.

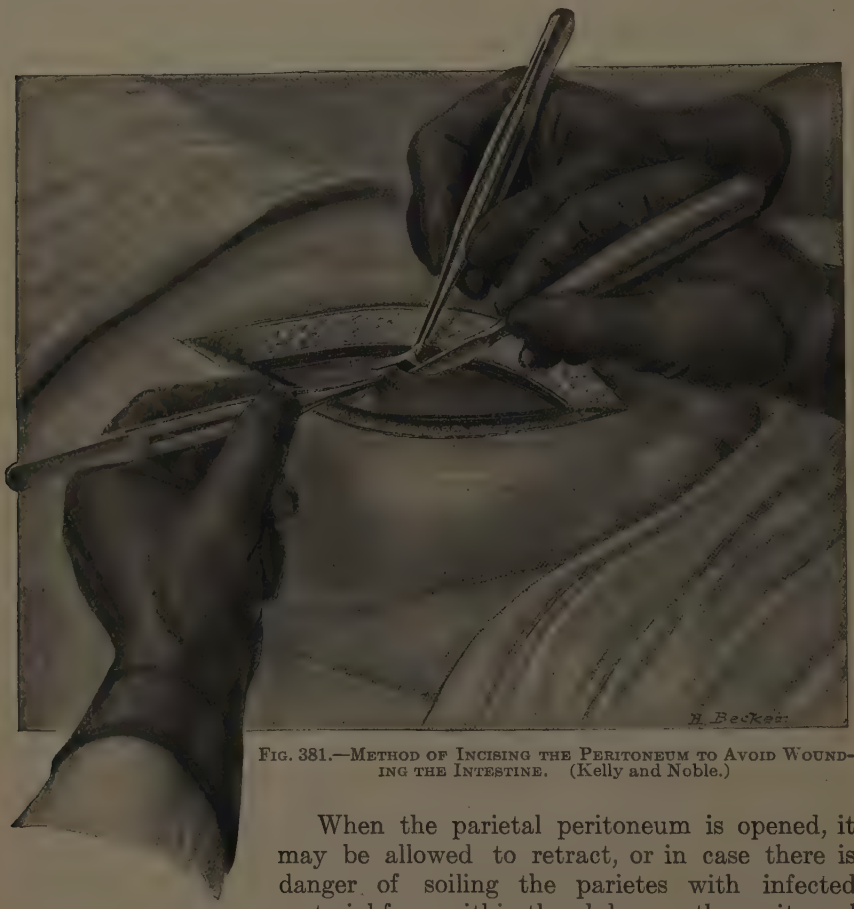

FIG. 381.—METHOD OF INCISING THE PERITONEUM TO AVOID WOUNDING THE INTESTINE. (Kelly and Noble.)

When the parietal peritoneum is opened, it may be allowed to retract, or in case there is danger of soiling the parietes with infected material from within the abdomen, the peritoneal flaps can be mobilized, everted through the opening, and held in place by the weight of radiating snap forceps, or by being fastened to the skin. Practically the careful disposition of wicks and packs will accomplish as much.

Examination of the abdominal cavity should be made with one or two fingers as far as practicable. If the examination proves negative the opening should be made long enough to admit the hand for a complete examination. Frequently a visual examination through this enlarged opening will reveal more than will a digital examination.

It is so rare nowadays that a competent surgeon opens an abdomen

without cause that he must bear in mind the fact that if he does not at once find the suspected lesion, in all probability there will be some *unsuspected lesion elsewhere* in the cavity to throw light upon the puzzle. More and more are surgeons recognizing that unnecessary laparotomies are the results of failure or inability to recognize a definite lesion that is present, rather than from the genuine absence of any lesion.

For *sponging*, surgeons use gauze, moist or dry. When moistened with normal saline solution, the peritoneal surfaces are less apt to be roughened and injured, and the after-pain and adhesions are minimized. If coils of intestine are held outside the cavity for any length of time they must be kept moist and warm with gauze or cloths soaked in normal salt solution. Shock is thereby lessened as well as the liability to the formation of adhesions. For a similar reason, when a long exposing incision is required in the early part of an operation, as for instance, in the delivery of a large solid tumor, the later steps of the operation being confined to a small corner of the abdomen, the exposed viscera should be protected from evaporation and chilling either by temporarily closing a major portion of the wound, or by using warm, moist packing that need not be disturbed until the time of permanent closure.

It is safer in the long run to *control all bleeding*, where possible, by ligature, whether it is in the wall or in the cavity. In order to reduce the sum total of necrotic tissue, it is best to clamp and ligate only the vessels when feasible. Hemostasis that relies upon crushing alone is dangerous, not necessarily to life, but to satisfactory after-healing. With reaction from the shock of operation, or with the restlessness that may follow, a small thrombus can be dislodged and cause a troublesome hemorrhage.

Rest of the wounded area is as important for sound healing of soft parts as of bones, but for a much shorter period. Rest of the wound-area does not necessarily imply rest of the entire body. Many positions may be assumed by a patient after laparotomy, provided the wound-area itself is not disturbed. The modern tendency is to confine patients in bed for very limited periods after the simpler operations. Too rigid quietude to secure local healing in feeble, anemic, and senile patients entails a risk of bronchopneumonia, bed-sores, loss of appetite, and mental disturbances. The danger to a patient who has been etherized for laparotomy is considerable. The normal efforts to expel mucus are checked. Under any circumstances some foreign and septic material is inhaled during anesthesia, and unless elderly and feeble patients are aided by change of position to free their respiratory tract it is not surprising that some of them develop serious bronchopneumonia. A shift in position that allows the patient to take deeper inspiration and to substitute one set of respiratory muscles for another helps to keep the deeper bronchi free of foreign particles, and to augment the circulation in the finer radicles, thus preventing the hypostatic edema that may follow operations in the elderly. It is probably far from harmful that patients recovering from ether vomit more or less. Much mucus

and septic material is expelled from the pharynx, mouth, and probably also from the bronchi in the combined efforts at vomiting and coughing that come before conscious abdominal pain begins.

ADHESIONS.

The tendency to form adhesions and to eliminate them after they have once formed, varies to an extreme degree in individuals. Certain peritoneal cavities tend to form extensive or universal adhesions on the least provocation, or even without apparent source. Such types are fortunately rare, but there is no way of determining them beforehand. So it is with the disappearance of adhesions produced by operation or inflammation. The rapidity and thoroughness with which most extensive crippling adhesions will melt away in certain cases is truly astounding. Between these extremes there are all degrees. It is a fact, however, that the peritoneum in a majority of patients tends to revert to the normal condition as rapidly and completely as the individual will allow. To explain the individual differences is beyond our power; they do not apparently always depend upon the virulence of the infection or trauma, in fact, the reverse is at times strikingly true. In many cases the rapid and appropriate formation of adhesions is a most important life-saving process. It is seen in many infections and in some operations. Protective adhesions form ordinarily within a few hours. They can be hastened and, as it were, trained at operation by suitable packing of gauze or other material.

To prevent adhesions in the ordinary case the surgeon should avoid rough handling and sponging, or irrigation with irritating fluids. Destruction of the endothelial lining means some extent of agglutination. Constant packing and repacking, especially with dry gauze, needless manipulations to determine data that should be recognized at once, rough retraction, and pinching of the intestines, exposure to the air and evaporation, all account for much of the postoperative colic and adhesions in aseptic cases. The main cause, however, is sepsis.

Adhesions once established may cause no disturbance or they may bring about fatal lesions. Their effects may appear at once, following operation or infection, or they may be postponed for many years. The symptoms may be slight, obscure, intermittent, or constant; sometimes they are fulminating. They may cause death directly, as when a band strangulates a coil of gut, or indirectly when they so distort an organ that its functions are seriously impaired. The latter is seen in adhesions that check the functions of the biliary tract, the stomach, pelvic organs, etc.

To deal with adhesions when encountered at operation requires judgment and experience. The recent, delicate types can be separated with the finger or by wiping with a sponge; these rarely bleed long or seriously enough to cause anxiety. Firmer adhesions that contain well-developed vessels must be ligated. Rough separation of adherent viscera may produce serious or annoying tears, requiring suture or

plastic repair. Old and firm adhesions that have existed for a year or more are usually free of vessels and may be cut without ligation.

It is well to avoid disturbing extensive adhesions that are obviously harmless, simply for the sake of destroying them. The viscera generally accommodate themselves to broad sheets of adhesions, and even if the latter are dissected away such extensive areas of raw surface remain that reformation is unavoidable, probably in the shape of bands or strings capable of doing more damage than the original type. If raw areas are unavoidably formed as a result of operation, it is well to cover as much of the surface as possible by infolding or by transplantation of normal peritoneum. Adhesions that form strings or bands or that by general contraction interfere with organic functions should be destroyed. Chronic adhesions of themselves are not the cause of pain except indirectly. By interfering with the functions of an organ they cause disturbances that may be insignificant or may be fatal. In diffuse agglutinating adhesions of the intestines it may be impossible to distinguish the various coils, and one or more anastomoses may be demanded to establish normal drainage. Occasionally, however, the surgeon encounters a case of almost universal massing of the intestines, secondary to some slight infection of previous years. Such entanglements can, by care and patience, be freed sufficiently to re-establish satisfactory functions, and in my experience the benefit has proved permanent. Adhesions that cause alarming distentions immediately after infection or operation are occasionally met with. In such a case the abdomen should be reopened at once and the trouble rectified.

Unfortunately, the serious complications, such as acute strangulation, chronic strictures, ptosis, etc., usually come many years after the causative lesion, which meanwhile may have been entirely forgotten by the patient. To prevent calamities such as these, as well as the early manifestations, it behooves the surgeon to use every precaution to prevent septic and traumatic lesions of the peritoneum.

The custom of filling the abdominal cavity with salt solution at the close of operation is advocated by many surgeons as a preventive against adhesive formations. Considering that the solution is entirely absorbed within a few hours, it is probably of very little practical value, but it is of value in supplying the loss of fluids and so preventing post-operative thirst. To prevent adhesions in some chronic types of peritonitis, sterilized air has been injected into the cavity with some success.

To reiterate that which we have previously urged, post-operative adhesions can be minimized or prevented by asepsis, gentle manipulation, avoidance of all unnecessary trauma with hand, instrument, or sponge, and of exposure to the air. So also, moderate peristalsis and stimulation of the secretion of peritoneal serum by the supply of sufficient fluids are important adjuncts after operation.

HEMORRHAGE.

Intraperitoneal bleeding should be carefully controlled by ligation, suture, or packing with gauze, preferably iodoform gauze. Occasionally

when there is troublesome oozing from a broad surface, it may be necessary to pack with gauze moistened in a solution of adrenalin. The actual cautery is of less value than gauze packing.

It is not safe to trust to compression with forceps or to torsion to control bleeding in the abdominal cavity, especially in long operations, or where the head-down posture has been employed. The post-operative reaction, the change of position, and the increase of venous pressure from vomiting may dislodge thrombi and start a serious or fatal hemorrhage. The symptoms are those of concealed hemorrhage, restlessness, air hunger, anemia, increased rate of respiration, etc. It must be remembered that the pulse-rate, just as in hemorrhage following contusions of the abdomen, may be slow to respond within the first few hours. A falling off in the tension of the pulse and a drop in temperature with cold extremities, however, is seen early. Dulness in the flanks, distention, and pain may be present, but they are late indices and confirm others that should have been recognized earlier. The compressible and rapid pulse that attends post-operative nausea comes at once after operation, and must not be confused with similar signs due to hemorrhage coming at a later period, after reaction from the operation shock has taken place. The treatment is, of course, reopening of the abdomen, rapid search for and control of the bleeding point.

In persistent oozing at the primary operations, where hemostasis is not satisfactorily complete, in spite of hot packs or irrigation, and yet the deligation of the larger arteries is not indicated, I have found clinically that a dose of adrenalin (20 to 30 minims) given hypodermically every hour or two apparently has a beneficial effect. A tourniquet about the thighs sufficient partially to control the venous return may be used in cases that cause apprehension.

DRAINAGE.

The question of drainage of the abdomen is dependent to a considerable extent on the experience and notions of the individual surgeon. Although drainage is used much less at the present time than in former years, and although the form of drainage is growing simpler and less bulky, yet the general rule is as potent to-day as ever—that in case of doubt it is safer to drain, if only for a day or two.

The purposes of drainage are in the main twofold. To encourage the focalizing of temporary septic material at a point whence it can be deflected from invading the general abdominal cavity, and thence the general lymphatic system; secondly, to establish an impermeable barrier about a point of infection, thereby preventing indefinitely the transportation into the lymphatics of a persistent infection.

The first is accomplished within twenty-four to forty-eight hours, the second may require weeks or months. Since the convincing experiments by German and American observers have shown that the most active and rapid absorption into the lymphatics takes place from the diaphragmatic and omental peritoneum, while the pelvic peritoneum

is very slow to absorb, posture has become a very important adjunct negatively as well as positively, in the treatment of peritoneal sepsis. The pelvis-low, or as it is known in America, the Fowler position, is used by surgeons almost universally where the danger of general sepsis from peritoneal sepsis is possible. On this basis patients are put to bed after operation in a half or even a complete sitting position, which is maintained for several days at least. Furthermore, it is safer to transport patients in the sitting position before operation where there is a probability of peritoneal sepsis. Cardiac weakness in patients of this class is dependent on cardiac changes secondary to general septic absorption. If the latter is minimized, rather than increased, by the position of the body, there is less to be feared as regards circulatory collapse.

The peritoneum is doubtless able to dispose of very large amounts of septic material, and it is assumed by many that drainage is consequently unnecessary in a large proportion of septic cases. The tendency to dispense with drainage is a practice that is justifiable as a reaction against the excessive and bulky methods of past years. But

FIG. 382.—CIGARETTE DRAIN.

there are three factors that must be considered in carrying this practice to the extreme. First, the individual equation as regards susceptibility to infection. This factor cannot be determined by any known reliable methods of examination. Judgment that comes with personal experience counts for much in estimating its value. Second, the virulence of the infection. The species and the presence of the organism may be quickly and quite accurately determined by coverslip examinations. But this does not differentiate the virulence of the individual case. Third, the presence or absence of distant foci of infection. This cannot always be determined with safety or accuracy at the time of operation. Consequently, if there is a reasonable doubt as to one of these factors, we believe that some form of drainage is conservative.

Absorbent gauze is the basis of most drainage material. It may be plain or medicated, preferably with iodoform. For temporary drainage thin rubber or gutta-percha tissue may be wrapped loosely about one or two strands of gauze (*cigarette drain*). The rubber prevents adhesions to the viscera and the parietes, and facilitates withdrawal. In unmistakably septic cases, as for instance in the gangrenous cavities of appendicitis, especially where there is oozing from indurated walls,

enough free gauze may protrude from the rubber envelope to fill the cavity, and the drain may be allowed to remain for four or more days until it is loosened by the softening of the tissues. A very convenient temporary drain is made by loosely rolling a small square of rubber tissue upon itself without gauze.

In draining a septic pocket through a clean peritoneal cavity, the action of the gauze upon the surrounding organs is to excite at once the formation of adhesions that block the passage of septic material into the clean peritoneal cavity. If there is danger that the protecting gauze may be displaced by the movements of the patient, it is well to build the gauze packing about a glass or rubber drainage tube, which acts as a support for twenty-four hours until the adhesions are firm, when it can be withdrawn. This is especially useful when packing firmly to control troublesome oozing.

In case of damage to the walls of one of the hollow viscera where there is uncertainty as to efficient closure, a drain acts both as a stimulant for the formation of protective tissue, and as a leader for the evacuation of septic material in case of later rupture.

If fixation of a gauze drain to some definite point is required, as in drainage of the common duct, in sutures of the ureter, etc., and yet the bulk of a glass drain and gauze pack would be inappropriate, the wick may be sutured to adjoining tissues with catgut, which, dissolving in the course of a few days, will free the gauze.

The so-called *stab-wound drain*, especially in cases requiring temporary drainage, is of great value. A small punctured wound is made at some distance from the main incision at a convenient point for drainage, the trespassed muscles are forcibly divulsed, and the drain is brought out through this opening, preventing infection of the operation wound, and minimizing the chances of hernia.

For over a year I have made use of the following method of drainage in practically every form and grade of infective peritonitis. It has proved most useful in gangrenous appendicitis especially. Through the original wound a cigarette drain and a rubber tube are placed as seems best, the distal ends being brought out through the stab wound. The first wound is then closed in layers with catgut as usual, the skin and subcutaneous fat, however, being closed loosely with figure-of-eight silkworm-gut sutures. This wound heals practically *per primam* and without hernia. The stab wound closes spontaneously soon after the drainage is withdrawn. I lay considerable stress on using the rubber tube, not so much as a drain, but to keep the stab wound open for the easy replacement of wicks, if such be necessary.

For the drainage of large cavities, especially where the wicks are to be removed gradually, a drain such as that which is known as the *Mikulicz drain* is very convenient. It consists of a square of gauze, to the center of which a stout piece of silk is fastened. This is packed in the cavity with the center at the deepest point, forming as it were, a capsule or pouch into which the necessary gauze wicks are packed, the free end of the silk being conducted outward through the middle

of the packing. The pouch may be sutured at any point with catgut, if there is a possibility of its being displaced, and it may be sutured to the parietes to prevent evisceration. By moistening the wicks they may be successively withdrawn in four to seven days, followed finally by the enveloping pouch of gauze which is turned inside out by means of the silk cord.

As soon as a cavity is lined with granulation tissue, that is, in the course of four to eight days, it is best dressed with some stimulating lotion, such as myrrh wash, a solution of permanganate of potassium, etc. Many small cavities and sinuses are made to persist long after closure would naturally take place by meddlesome and too vigorous packing.

In using *gauze packing*, especially in cases of hemorrhage, it must be borne in mind that it becomes practically impermeable to fluids at the end of forty-eight hours, and that it may form a stopper-like obturator beneath which blood and pus may accumulate as in an artificial cavity. Re-infection may take place rapidly, and it will be necessary to remove the packing early when the pulse or temperature indicate trouble.

Iodoform gauze is still used by many surgeons, especially in infected cavities. Its use in large quantities in debilitated or nephritic patients must be guarded, because of the danger of poisoning. This is indicated by restlessness, headache, fever, rapid pulse, delirium, and hematuria. The danger is somewhat exaggerated, and symptoms ascribed to iodoform can usually be better explained by septic peritonitis, etc. In fifteen years of almost unlimited use, however, I have seen its toxic effects a few times.

Late suture of granulating wounds after long-continued drainage is useful to prevent hernia or a wide scar. If hernia results, it is best repaired at the end of several months, when the tissues are no longer thick and inflamed, and when approximation can be made with anatomic accuracy.

CLOSURE OF WOUNDS.

The general rule, when it can be carried out, is to close an abdomen layer by layer, with careful apposition of like structures, without undue tension, and with obliteration of all dead spaces. Hemostasis should be as complete as possible. Local drainage should be used only when the walls are infected. In very fat walls, with escape of liquid fat, or in extensive dissections, when there is likely to be an outpour of lymph, it is well to provide capillary drainage for a few days to prevent the formation of dead spaces or infecting foci. The several layers are unequally resistant to contamination. Thus, the peritoneum disposes of infection much more readily than fatty tissues. These, on the contrary, are less resistant than the musculo-aponeurotic layers. It is not uncommon to find a superficial sepsis that remains superficial without marring the integrity of the united aponeurosis. If the latter become infected, however, the peritoneum will remain agglutinated and

undisturbed. Provided an infection is detected early and drained properly, hernia rarely results.

Under stress of urgency the walls may be closed by through and through sutures that approximate the tissues in bulk, but with never any certainty, layer against layer. Owing to the ability of normal tissues to accommodate themselves to abnormal conditions, hernias do not often follow suture in bulk, but they are much more rarely seen after careful layer suture.

Unless the aponeuroses are thinned and stretched by chronic pressure from within, as in umbilical hernias, enteroptosis, or in paresis

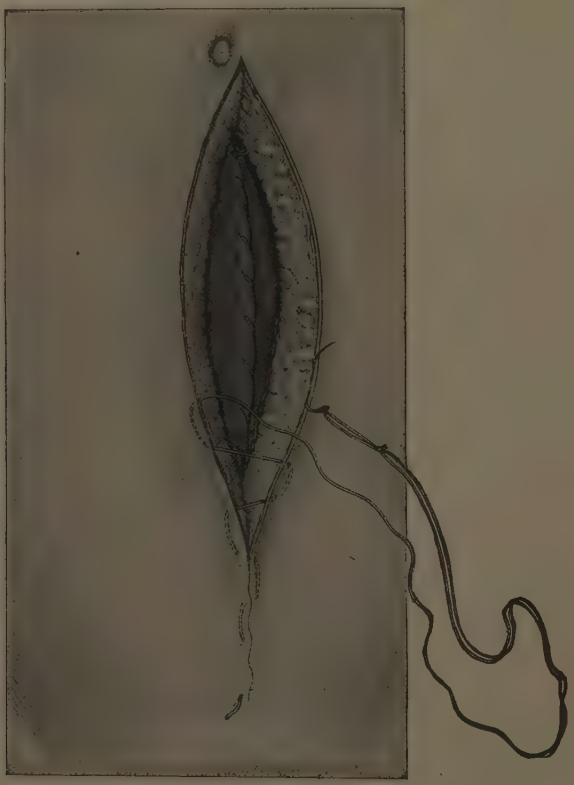

FIG. 383.—INTRODUCING THE SUBCUTICULAR SUTURE. (Kelly and Noble.)

secondary to destruction of the nerve supply, there is no advantage in overlapping an aponeurosis. The power of repair of a healthy aponeurosis is similar to the repair that takes place in the accurate apposition of healthy tendons; it is rapid, strong, and permanent, the new tissue being the outgrowth from the fascia and having much the same characteristics as the tissue which arises from the tendon sheath. To strengthen a healthy aponeurosis by overlapping is much like trying to strengthen a fractured bone by overlapping the ends of a fracture.

The peritoneum is best sutured with an absorbable material. The edges may be brought together in eversion, bringing surfaces instead of edges together and leaving no free border within the cavity to become possible sources of adhesion. But when the wound is a clean one, and free from laceration, eversion is not necessary. As a matter of fact, adhesions to the peritoneal scar are not frequent in clean operations, and if present are rarely of any moment. We are much more apt to find adhesion at some distant point where the endothelium has been injured by rough sponging or forcible retraction.

At the extreme ends of the linea alba, where the peritoneal layer tends to shrink away from the aponeurosis, it is best to obliterate the dead space by suturing the peritoneum forward to the overlying tissues.

The aponeurosis, whether in one or more layers, should be brought into accurate apposition by silk, wire, or absorbable suture material. A continuous over-and-over, or a lock-stitch suture is preferable to an interrupted suture, as a more even tension is thereby secured. Gaping muscular bellies that have been split lengthwise can be approximated by a running suture that embraces a considerable quantity of tissue with the least amount of constriction sufficient to secure apposition.

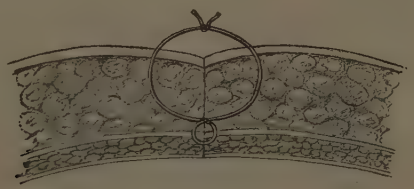

FIG. 384.—THE FIGURE-OF-EIGHT SUTURE.

The deep superficial fascia may be separately sutured, but this tissue is poorly nourished, and anything that causes a necrosis may be sufficient to cause a mild local infection.

The skin may be closed as best suits the surgeon, by subcuticular suture (Fig. 383) with wire, silkworm gut, or catgut, or by a continuous lock-stitch suture of horsehair, silk, etc. Aseptic adhesive plaster may be used, especially in the slanting so-called scarless incisions, but the subcutaneous tissues must be carefully sutured beforehand to prevent later stretching of the scar. Small metal clips (Michel's) are much used in some countries, but their superiority over suturing has not been demonstrated.

The use of absorbable sutures in the aponeurotic layers necessitates the employment of sutures to take the tension from absorbing sutures during sudden strain incident to vomiting, coughing, etc. These sutures are temporary and are not needed as soon as agglutination has advanced far enough to bear the usual strain, that is, after ten or twelve days. The simplest form is the so-called *figure-of-eight silkworm-gut suture* (Fig. 384). This is so placed that a short bight is placed around the aponeurotic edges that are in apposition, while the loose, long bight includes the skin and fat. Any sudden tug on the aponeurosis tightens

the deep loop at the time when it is needed. In elderly people, or in those with malignant disease, buried silk or linen may be substituted for the silkworm-gut, enabling the patient to sit up and get out of bed at once after operation.

All the layers may be closed individually with running sutures of bronze or silver wire, or silkworm-gut, the free ends emerging above and below each angle of the wound. At the end of twelve or more days each strand is loosened by sawing it to and fro, and then withdrawn, leaving a firm union without any foreign material.

Through-and-through suturing is a favorite method with many surgeons, on the basis that it is rapid, holds firmly, and minimizes dead space, hemorrhage, and sepsis. It may be combined with layer suture in addition, if desired. When time is of the utmost value it is undoubtedly the method of choice. The silkworm-gut, silver wire, or silk is preferably passed from within outward on both sides through all the layers at intervals of about one-half inch in order to avoid carrying bacteria from the skin into the deeper layers, or they may alternate with figure-of-eight sutures, the latter not including the peritoneum. After all the sutures have been placed, it is well to draw them taut, pulling away from the line of incision in order to drag the wall forward, and to prevent the entanglement of any of the viscera. A running catgut or silk suture can then be placed in the aponeurosis, after which the deep sutures are tied in succession. The objection to this mass suturing, especially when the individual suture is not applied to the aponeurosis, is the uncertain approximation of the individual layers and the unnecessary amount of constriction required to draw the bulky wall together. It does not obliterate dead spaces any better than careful layer sutures, especially if in the latter each layer is drawn up against its overlying layer by a continuation of the deeper suture into each successive superficial layer. Tension is less evenly distributed and the discomfort to the patient is much greater. Infection from without is more easily conducted along rigid cutting sutures than is the case in tier suturing.

In suturing a wound that has been made through scar tissue, it is well to dissect laterally for a short distance, in order to identify and to approximate corresponding layers. If there are areas or strips of anemic scar tissue, it is best to remove them.

DRESSING OF WOUNDS.

After the ordinary wound is closed very little in the way of dressing is required. A simple layer of gauze and collodion (cocoon dressing) is ordinarily sufficient. To prevent the patient from disturbing the seal it is well to apply a swathe for a few days. Instead of a cocoon dressing, the gauze may be held in place with adhesive straps, but it is important that the gauze next the line of incision does not slip nor irritate by constant friction. In a clean muscle-splitting wound all dressing may be dispensed with in ten or twelve days.

In patients with fat abdomens, where the weight of the wall drags laterally from the scar, it is important to overcome the dragging by a snug swathe, or adhesive strapping, for about three weeks, when the scar tissue on the skin should be strong enough to prevent stretching. Extensive wounds, eight inches or more in length, need support for about three weeks, after which it may be discarded. Where muscles have been cut and sutured, external support is necessary for about three weeks. So also in wounds involving loss of tissue and requiring tension sutures.

Except in obese patients, following the ordinary operations, any reasonable amount of exercise or strain should have no effect on the scar after three weeks, provided healing has been aseptic. Long lateral wounds with destruction of motor nerves impel the subsequent use of abdominal supporters to aid the paralyzed muscles in resisting the pressure from within.

Drained wounds that develop hernia should be supported until all evidences of inflammation have subsided, when they should be closed by secondary suture.

Many surgeons apply *silver foil* to freshly made incisions, as it apparently lessens the tendency to infection from the epidermis. The use, however, is not a universal one, and apparently as good results are reported without as with it. So too, with the various dusting powders, boric acid, subiodid of bismuth, iodoform, etc. Each has its advocate, but, as a rule, the simpler the dressing, the better. Most wound infection originates at the time of operation from some slight error in technic, rarely does it come after final suturing. Rigid tension sutures that produce small necroses may serve as atria for external sepsis. Their power for harm may be diminished by some of the antiseptic applications, like silver foil, mentioned above.

Large, confining, rigid dressings are a source of discomfort to patients, and are rarely needed.

AFTER-TREATMENT.

The after-treatment in a majority of the routine cases should be as simple and undisturbing as possible. Much of the discomfort that patients suffer depends upon their individual makeup, the preparation for operation, and the technic at the operation itself. With every patient there are certain fundamental discomforts that are present in some degree. These we will consider in detail. The rare complications and sequelæ are numerous and must be considered very briefly.

Every patient after a laparotomy suffers to some extent from shock, pain, nausea and vomiting, thirst, meteorism, and sleeplessness. All can be reduced to a minimum by preliminary catharsis as outlined earlier, by gentleness in the operative manipulation, and by asepsis.

The treatment of shock does not differ to any extent from that which is used under other circumstances. Warmth, quiet, early administration of salt solution by rectum or under the skin, and adrenalin include the usual means at our disposal. (Cf. Vol. I., p. 938.)

Pain independent of the discomfort of intestinal gas is rarely severe or lasting. A small dose of morphin during the first night following operation is advisable, but it should rarely be repeated.

Nausea or vomiting varies within very wide limits. Nervous, apprehensive patients, especially those that have had unfortunate experiences at a previous operation, will suffer much. Rough handling of the viscera, large drains and diffuse infections with meteorism, will perpetuate nausea and vomiting. In aseptic operations, the administration of the anesthetic has as much to do with post-operative vomiting as any one thing. The etherizer who can keep his patient anesthetized with the minimum quantity of pure ether will inflict the least post-operative discomfort upon his patients. The use of ethyl chlorid, chloroform, or nitrous oxid in the beginning of ether anesthesia lessens the nausea because it lessens the total quantity of ether given. Practically the same result is obtained by the skilled anesthetizer who uses ether throughout. In sensitive patients, especially when they have had previous distressing experiences, or in others in whom we wish to reduce the straining to a minimum, it is well to wash out the stomach thoroughly before the patient recovers consciousness. This can be repeated afterward, if necessary, almost invariably with intense relief. In the vomiting that comes from reversed peristalsis in septic cases, in those with aseptic intestinal paresis, and especially in the acute gastric dilatations, gastric lavage is indispensable.

There is no drug in my experience that has the least power to control nausea and vomiting. Patients are allowed to drink liberally of plain cold water as soon as they are conscious and complain of thirst. They generally vomit the first portions taken, thereby partially washing out their stomachs with little strain or effort. A half dram of tincture of iodin may be added to a glass of water to produce emesis if it is not necessary to use the stomach tube. Cracked ice, in my experience, is worse than useless except in very rare instances. A persistent nausea or vomiting will often cease at once if the patient is propped up in a half-sitting position, thus securing normal drainage into the intestine.

The inhalation of oxygen or vinegar will lessen post-operative nausea, according to some surgeons. So, too, with mustard paste applied to the epigastrium. But in the long run, skilled anesthetizing, skilled technic, lavage, and early establishment of peristalsis are of more significance than anything else.

For thirst, which may be quite distressing, we may rely to some extent on a liberal ingestion of fluids before operation, on filling the abdominal cavity with salt solution at the time of operation, on liberal quantities of water given by mouth after operation, and on salt solution given by rectum. Here the establishment of peristalsis is most significant.

For meteorism or for gas pains without meteorism, the most potent weapon is prevention. The large dose of castor oil, gentle manipulation and asepsis count most. In the average aseptic case it is important to establish normal peristalsis within twelve, or at most, twenty-four

hours after operation. A simple soapsuds enema may accomplish this. The passage of fecal matter is immaterial, the passage of flatus is a *sine bua non*. A most useful enema given into the lower sigmoid contains a pint of milk and a pint of molasses, to which a half ounce of turpentine may be added. This is one of the most satisfactory routine enemata in my experience. A more drastic enema consists of 2 oz. of epsom salts and glycerin, and 1 oz. of turpentine. Enemata which contain alum are also quite effective. The effects of an enema may be supplemented by the passage of a rectal tube, which is allowed to remain for several hours, if necessary.

In the acute rapid distentions of septic patients, or occasionally after clean operations, it is well to give atropin combined with morphin, if there is pain, to employ gastric lavage and repeated enemata. In severe cases an enterostomy may be demanded.

In this connection it is well to remind surgeons that an acute gastric dilatation will simulate an acute intestinal distention. In such cases the expulsion of gas with enemata and by the rectal tube, though satisfactory, does not lessen the abdominal distention. The stomach tube will clear up the diagnosis and copious and repeated lavage will save many lives.

The sleeplessness that comes in the first night after operation is almost inevitable, and it is well to warn the patient beforehand. That which comes in the second night is usually less, and is caused, for the most part, by pain resulting from gas. There are no drugs that are of value. As soon as peristalsis is established, and as soon as the patient can begin to take nourishment, even in small quantities, by mouth he will secure a sufficient amount of sleep in the course of twenty-four hours. The treatment of the sleeplessness and delirium of alcohol and drug habitués, does not differ from the treatment under other conditions.

The nourishment of patients consists, first, in allowing sufficient water by mouth or bowel to control thirst, and to replace the loss of body fluids. As soon as nausea subsides patients may be allowed liquids that contain some nourishing elements, such as albumin water, orangeade or lemonade, thin broths, followed by soft solids. Many patients who complain of slight nausea for a few days after operation, and who revolt against liquid diet, will eat and digest solid food without trouble, the nausea disappearing at once. The sitting position facilitates feeding very much.

Some of the remaining symptoms that must be met at one time or another will now be briefly indicated.

Persistent retention of urine is rare, provided the first urine secreted is not drawn by catheter. Rarely does a patient secrete sufficient urine to cause discomfort under eighteen hours, and then he should be encouraged in every way, even being allowed to sit up to void urine spontaneously. Urinary suppression must be met by large quantities of salt solution by rectum, cupping, hot baths, etc. Constipation is combated by diet, plenty of fluids, laxatives, and enemata. Backache, cramps in the legs and thighs, and other discomforts that come from

strained positions, enforced quiet, etc., are often annoying. Massage, alcohol rubbing, support by pillows or folded sheets, and change of position will do away with much of the discomfort.

Slight cough and hiccough rarely justify treatment by drugs. The severe coughs from bronchitis or pneumonia, and the severe hiccoughs of sick patients are difficult to control, and distressing to the patient. The opium alkaloids or other sedatives may be required. In the cough that comes on at once after ether and that is apparently the result of bronchial irritation with marked edema, atropin in full and repeated doses will give astounding results.

Among the grave complications and sequelæ that any surgeon is liable to encounter, a few only will be briefly mentioned.

Post-operative hemorrhage indicated by restlessness, air hunger, anemia, and a tardy acceleration in pulse, must be treated by re-opening the abdomen if there is any chance for life, salt infusion, or as Crile has demonstrated, direct blood transfusion.

Ileus from mechanical causes (twists, bands, invaginations, etc.), demands early operation. It usually comes several days after the primary operation, and though simulating peritonitis by vomiting, distention, and obstipation, it occurs in a case progressing satisfactorily without the temperature and pulse of an infectious process. It is more likely to be attended by acute colic, and the distention may be asymmetrical, the active peristalsis of the coils being visible through a thin abdominal wall.

Peritonitis in an abdomen previously clean is marked by rise in pulse and temperature, spasm, vomiting, and distention. It must be treated as if it were primary. The possibility of a foreign body left in the abdomen at operation must ever be in the surgeon's mind in such cases.

Mesenteric thrombosis is not common after operation and is rarely amenable to surgical treatment.

The acute pulmonary inflammations, whether due to direct irritation of the ether, to irritation of septic materials, to emboli, or to direct infection by the pneumococcus, are always serious. As indicated above the edemas and milder types of bronchitis are best controlled by atropin. These types and the septic inhalation bronchitis can be prevented by careful administration of the anesthetic, control of the secretions of the mouth during operation, cleansing of the oral cavity beforehand, and avoidance of bodily exposure. The typical lobar pneumonia may come on during convalescence; it may also be incipient before operation. Its treatment does not differ from that laid down in all text-books.

Phlebitis, usually of the left saphenous vein, comes in about 2 per cent. of all abdominal operations, according to Cordier. Its cause is not definitely established. It comes usually in the second or third week following operation, and is marked by gradually increasing pain and tenderness along the vein, elevation of pulse and temperature, and edema of the distal member. Detachment of the thrombus, as well as gangrene, is rare. The majority of cases come after aseptic operation

in the lower abdomen (appendix, pelvic organs) in anemic patients. The treatment consists in elevation of the affected limb, and poultices in the acute stage. Later, it is necessary to wear elastic compression on the limb, and to compel the patient, for a time, to walk with crutches. Convalescence is slow and tedious, and in some instances there is permanent edema of the leg and thigh.

Parotiditis is a rare complication, probably from septic invasion through the duct. It must be treated by hot poultices and incision, if necessary.

Acetonemia is not rarely seen, especially in children with septic infections. The delirium, persistent copious vomiting without elevation of the pulse and temperature, the sweetish odor of the breath, and the presence of acetone in the urine are characteristic of the condition. Alkalinization of the blood by large doses of bicarbonate of sodium given by mouth, rectum, or intravenously, is the best known method of combating the condition.

Occasionally the surgeon will see an apoplexy, caused by or concomitant with an abdominal operation, in patients already predisposed thereto. A slumbering epilepsy may be awakened by operation. Some patients develop severe and puzzling skin eruptions that retard convalescence, others exhibit mental changes that may remain permanent. The post-operative functional neuroses may be very baffling and persistent. I believe it is fair to say that injudicious after-care is much more responsible for this latter condition than the operation and immediate convalescence.

As a conclusion to this chapter, it may be well to consider the question of *exploratory laparotomy*. Up to within a few years it was considered an opprobrium to resort to laparotomy for diagnosis. We are confident that experienced surgeons of the present time feel that the disgrace of not making incisions for confirmatory diagnosis is a much more frequent and lamentable one. After a *thorough, conscientious endeavor to make a diagnosis in obscure cases*, it is the part of the conservative and humane physician to advise exploration, if there is a remote chance that benefit may be derived from surgery. With the understanding that the exploration is a major operation, to be undertaken only by a surgeon capable of meeting any surgical problem that may arise, it seems unreasonable to object to interference when such interference offers the best hope for accuracy in diagnosis and treatment.

CHAPTER XLVI.

SURGERY OF THE ABDOMINAL WALL.

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SUPPURATION OF THE ABDOMINAL WALL.

The infections of the abdominal wall, as in other regions of the body, may be primary or secondary, diffuse or local, acute, subacute, or chronic. The anatomic arrangement of the muscles, fasciæ, and peritoneum, give to these infections more than ordinary interest. The primary infections are seen in erysipelas, furuncles, and carbuncles, from wounds, burns, etc. The more extensive burns or infections may be associated with severe intestinal hemorrhage. Their diagnosis and treatment in general does not differ from that of similar affections elsewhere. Any of the diffuse infections originating in one layer may successively invade the adjoining tissues. Local intramuscular infections may mark the termination of diffuse infections, may start as traumatic hematomata, as metastases from distant infections, or they may be the result of direct invasions from abdominal or skeletal foci. As the result of extensive muscular or fascial destruction we may find more or less extensive herniæ which will demand plastic repair, incorporation of some supporting foreign material, such as filagree, horsehair cloth, celluloid plates, etc. In case operative construction is not feasible, especially when important motor nerves have been destroyed, the patient must be content with some form of supporting truss or binder.

One type of intramuscular infection that is important because of its obscurity is found in the oblique muscles or in the rectus, and is apparently spontaneous in origin. Sometimes a history of mild trauma, such as a strain or a blow that had passed unnoticed at the time, may be elicited. Severe blows, on the contrary, are more likely to cause intra-abdominal mischief, though they, too, may occasionally be followed by hematomata and abscess. The more common, insidious types are marked by general symptoms of infection and local signs that suggest peritoneal inflammation. A tender tumor, localized, not changing its position with respiration, accompanied by a local spasm that suggests a localized peritonitis, may easily deceive a careful observer. We may find nausea or vomiting. Muscular soreness interferes with normal defecation, and if there is, perchance, a history of intra-abdominal infection at some earlier period, or a recent history of malaise, it is not difficult to conclude that the lesion is inside the abdomen rather than

in the parietes. Similarly, an infected sarcoma of the parietes may mimic an intra-abdominal infection. Abscesses found in the obliques or in the rectus are somewhat limited by the natural bounds of the muscular fibers, that is, by the fusions of the sheaths laterally, or by the transverse lines. They may open inward, though this is rare, or through the skin. Subacute abscesses may accompany typhoid fever, usually during convalescence. They form in the subcutaneous as well as in the muscular tissues. In the latter situation they originate as hematomata that are secondary to rupture of the muscular bundles.

Infection in the properitoneal space, between the peritoneum and the fascia transversalis, may originate locally, by invasion or by metastasis from distant foci. In this layer the diffusion may be quite extensive, especially in children, invading practically the entire peri-peritoneal tissues. In a case of Alexandroff's there was a collection of pus extending from the diaphragm to the umbilicus in the median line and laterally nearly to the iliac spines. Pust from a subphrenic abscess, from osteomyelitis of a rib, vertebra or pelvic bone, from appendicitis, an infected urachus or pelvic genito-urinary organ, or from a perirenal lymphangitis may serve as the starting point. The abscess may break along the groins, at the umbilicus, or by direct destruction of the overlying tissues at any place. In case of a diffuse invasion, the local signs are obscured and the source may be determined only with difficulty. Any one of the parietal strata may be infected from septic foci within the abdominal cavity. from ulcerations of malignant visceral growths that have become adherent to the wall, or from perforation through the visceral wall of foreign bodies like fish-bones, pins, sponges, etc.

Abscess of the prevesical space (space of Retzius) must be classed by itself, although it may escape the bounds of this region and invade other areas and strata by natural inflammatory infection. This space is bounded, anteriorly, by the fascia transversalis and the pubic bone; laterally, by the umbilical and the vesical arteries; below, by the parietovisceral reflection of the pelvic fascia; above, it extends to the semilunar fold, or even to the umbilicus where drainage of an abscess may take place spontaneously. Lymphatic trunks and small glands are found in this space, the so-called interrupting glandular nodules of Poirier and Cunéo, which are continuous with the lymphatic network of the prostate, seminal vesicles, vasa deferentia, and the terminal ends of the ureters. Hence, infections which appear here are usually secondary to some focus outside this space. Occasionally, an infection appears to derive its origin from the deep inguinal lymphatics so far as can be told at operation. As elsewhere, trauma may have a definite bearing on the origin of these infections. The various pyogenic organisms, including the gonococcus, may be found on examination. By following along the fascial planes an infection starting even in the neighborhood of the cæcum may manifest itself in this region as well as higher up in the abdominal wall. General signs of sepsis, a local tender tumor in the pubic region attended by symptoms of disturbed function of the bladder, should arouse suspicion of a phlegmon of this space. On rectal or

vaginal examination we will find fulness and tenderness behind the symphysis, often extending into one of the lateral walls. The false spasm of the abdominal wall, together with the vomiting and internal disturbances that are so frequently found with infection of the space of Retzius, must be carefully differentiated from the true spasm and symptoms of a peritonitis, a differentiation which is possible only on careful and thorough examination. A history of preceding infection in any one of the neighboring genito-urinary organs should serve to turn the attention to the extra-peritoneal inflammation. As a matter of fact, patients with this type of infection are not infrequently referred to the surgeon as cases of appendicitis or salpingitis.

Treatment.—The treatment consists in incision and free drainage, which should be carried to the originating focus when possible. Occasionally the pus will have burrowed beyond the limiting fascia and an abscess of the rectus will be the most evident lesion. On opening the latter, search for a possible origin behind the pubes must be made.

Infections secondary to visceral inflammation or to **malignant tumors** are not infrequent. A benign or malignant ulcer of the stomach may become adherent to the anterior wall, and, as the process of necrosis or digestion advances, the parietal wall itself will become invaded, followed by abscess and fistula. Death from starvation may follow persistence of a jejunal fistula. A malignant ulcer may engraft its tissue upon the walls of a secondary parietal abscess or fistula. Similar steps follow in the wake of tuberculosis and actinomycosis of the intestines, while foreign bodies penetrating the wall from within the intestinal tract may start a parietal infection. Acute secondary abscesses must be laid open freely and drained. A fistula secondary to a benign gastric ulcer must be dissected out and the originating lesion dealt with by inversion, excision, gastro-enterostomy, or other appropriate measures.

Cold, *i. e.*, **tuberculous abscesses of the parietes** may originate in a lower dorsal or lumbar vertebra or in a rib, the pus burrowing forward at times to the linea alba, but usually pointing in the antero-lateral wall. In the same way a focus in one of the pelvic bones or in the hip may push forward to appear near Poupart's ligament. Primary tuberculosis of one of the parietal aponeuroses is not very rare. Operation will disclose a local lesion which can usually be entirely dissected out in the latter case.

TUMORS OF ABDOMINAL WALL.

Various types of superficial connective-tissue tumors form here as elsewhere. **Nævi** may be found as small, harmless tumors, or they may spread over such extensive areas as to be beyond the reach of the knife, and threaten life. In those that cannot be excised, treatment by subcutaneous injections of boiling water is of value.

Warnek has reported a unique case of **angioma hypertrophicum** occupying an entire section of the rectus, which was successfully excised.

Simple **papilloma**, not of the umbilicus, is occasionally found. It may be radically excised.

Fibroma molluscum, either localized in the wall or as a manifestation of a general skin lesion, appears as a soft, painless, non-adherent tumor, slow in growth. As the tumor develops it becomes pedunculated and may attain great size. The pedicle is richly supplied with vessels, and, as these tumors tend to degenerate and become sarcomatous, they should be excised in the early stages.

Cutaneous sarcomata may appear as a malignant degeneration in benign growths, or they may be part of a general sarcomatosis. The prognosis is bad, especially where there is pigmentation. When rapidly growing, they soon invade the underlying structures and the viscera. Early excision rarely gives more than temporary relief. The *x*-ray, or Coley's serum is justifiable, if only for palliation, especially when excision is not possible. The diagnosis is made by the recognition of diffuse, irregular nodules of rapid growth, emaciation, and the examination of an excised nodule.

Sarcomatous degeneration of *warts and moles* is frequent enough, as shown by Keen, to emphasize the need for early excision.

Lipomata are found in any one of the three strata of normal fat in the abdominal wall. The subperitoneal layer, both of the anterior and posterior walls, shows quite a predilection for the formation of these tumors. We may look for them in the anterior wall, where there is, physiologically, a marked mobility of the peritoneum, as about the bladder, and in the epigastric, inguinal, and femoral regions. In the flanks they originate near the erector spinæ muscles.

The small lipomata, seen so frequently above the umbilicus, close to the median line, may precede or accompany a hernia, for which they are easily mistaken. Originating as they do, from the properitoneal layer, they appear and disappear like a hernia, and not infrequently are attended by colicky pain and distress. Their connection with the properitoneal fat may be cut off and their true origin be obscured. They emerge close to the median line, in the course of one of the small vessels. The tug upon the tumor draws the peritoneum forward, and an internal dimple is formed, which serves as the point of attack for a hernia, generally of the omentum. At one level we may find a small hernia with its preforming lipoma, while nearby we may find a simple fatty tumor, the forerunner of a future hernia. This combination of lipoma and hernia is apt to be found in patients with hernia elsewhere. Adult males suffer more commonly than others, but general obesity apparently plays no causative rôle. Following injury a small lipoma that has perchance existed for some time may attract the sufferer's attention, and the accident may be blamed as the cause of a true hernia, with the various physical and psychic symptoms. It may be necessary to explore surgically in order to determine the true pathologic condition. According to Lothrop, however, there is no recorded case where a single properitoneal lipoma has formed as a consequence of traumatism. Rarely the symptoms may be severe; in general they resemble those

which attend an epigastric hernia. Why a single fatty tumor in the epigastrium should exhibit such marked symptoms as pain, nausea, and vomiting, is not clear, but the fact is well established. As a rule, they rarely are larger than the finger-tip, while the lipomata elsewhere in the abdominal wall may grow very large. The diagnosis in the epigastric type is made by the presence of an impulse on coughing, partial or complete reduction, occasionally malnutrition from disturbance in the digestive functions, and neurasthenic stigmata. Elsewhere in the abdominal wall we find as characteristics a tumor of slow growth, semi-fluctuating, absence of emaciation, barring, of course, the retroperitoneal lipomata, which will be considered later, dulness, or modified transmitted tympany. The large lipomata, especially with fibrous elements, may become malignant. This applies mainly to the retroperitoneal types.

These tumors must be differentiated from various intra-abdominal lesions that produce dyspeptic symptoms, from gummata, sarcomata, and the various cysts and fibromata. The tumors are best enucleated before they attain large bulk, the prognosis being good. In the epigastric type the presence of a co-existing hernia must be considered.

Fibromata or the so-called **desmoids** of the abdominal wall are fairly common and important. Their place of origin is, for the most part, in the posterior sheath of the rectus, according to Olshausen, in ruptures which take place there during pregnancy. Rarely do we find them in the sheath of the oblique muscles, or intimately connected with a bone. In three-fifths of all cases they arise in women during pregnancy, and therefore they are found in women usually between the ages of twenty-five and thirty-five, but in men they are found at a later period of life, that is, thirty-five to fifty years of age. Occasionally a case is reported as congenital or in advanced life.

Most tumors are single, but at times they are multiple or they appear in succession in different locations. They have a predilection for the lower half of the abdomen, on the right side rather than on the left. Originally spherical, they may be pressed into various modified shapes by the muscular fibers through which they are forced, and thus we may find them oval, flattened, or even shaped like a collar button. Their rate of growth may be slow, or when coming during pregnancy, rapid. In the latter case they may shrink after parturition. The usual size is that of a walnut or an egg, although individual cases are reported where they have reached an enormous size, the characteristics being those of a fibromyxoma.

Microscopically, we find them as pure fibromata or fibromata with cell infiltration. The presence of cellular elements with rapid growth, however, does not necessarily establish malignancy. Nevertheless, the benign types may degenerate to malignant growths. Others may become calcareous or they may ulcerate. The typical tumors are hard and solid, with a firm capsule more or less adherent to the surrounding tissues. The knife creaks in cutting through the growth, and the cut surface has an aponeurotic-like appearance with a definite sheen. Others

will show evidences of hemorrhage, but they do not show signs of fatty degeneration. A diagnosis of sarcoma is easily ventured on the basis of cell aggregations, especially in the rapidly proliferating types where one finds round or spindle cells in considerable numbers. Occasionally, the clinical after-history is the only means of establishing a definite differential diagnosis.

Fibromyxomata, and **fibromyxosarcomata** are types that are also found, but pure myxoma is said by Pfeiffer to have been reported but once. Even the so-called fibromyxosarcomata are not necessarily malignant.

Although the majority of fibromata grow from the posterior sheath, they tend to push forward rather than backward. In the latter case it is difficult to differentiate them from intra-abdominal tumors. The diagnosis in the typical cases is not difficult. We find small, hard, well-defined tumors coming generally in child-bearing women, increasing with pregnancy and diminishing afterwards, causing only the slight discomfort that comes from pressure and the stretching of muscle fibers. They are generally superficial and can be moved laterally, but not up and down. Glandular involvement is not found except with ulceration. They must be distinguished from lipomata, cysts, collections of blood or pus, gummata, etc. The deep tumors pushing into the abdominal cavity can only be differentiated by operation.

The *treatment* is surgical. As they increase during pregnancy it is better to remove them early. The large growths may require extensive dissections, even involving considerable areas of the abdominal wall when some form of plastic closure will be demanded. The immediate mortality should be small, but as much cannot be said of the late mortality. Pfeiffer found that in men about half died later with recurrence, while in women only about 10 per cent. so died. The recurrences usually came within a year, occasionally after longer intervals, and they were always local. On this basis we should emphasize the importance of early and complete removal when the tumors are small and apparently innocent.

Myoma, independent of the round ligament, has been seen a few times, but its origin is obscure.

Primary cancer of the abdominal wall is very rare and merits no special consideration here. Secondary cancer is more common and comes, usually, by extension from a malignant growth in some internal organ, such as the stomach. Sometimes a cancer of the wall may be ingrafted on a fistula which has followed a spontaneous perforation of a gastric ulcer, but usually the invasion is direct from the gastric carcinoma itself. In the inguinal regions malignant nodes infected from the pelvic viscera may invade the abdominal wall. The treatment is purely palliative.

Echinococcus cysts are rarely found in the abdominal wall, as compared with other regions of the body. When present they will be found for the most part in the properitoneal space, between the navel and the pubes (Treuberg). Madelung found them most commonly

in the lumbar region, and next about the umbilicus. According to Most, they take their origin from the sheaths of the vessels. Slow in growth, they show only slight pressure symptoms, but if secondarily infected, patients suffer from the pain, tenderness, and other symptoms of sepsis. Becoming septic may break down, and discharge spontaneously. The diagnosis is not easy. A cystic tumor of slow growth, extending perhaps over a space of many years, the recognition of intra-abdominal cysts, if such exist, and slight general symptoms will suggest the possibility of a hydatid. Exploratory incision with protection against soiling of the cavity, rather than aspiration, is to be urged. The treatment consists in complete extirpation of the sac, if possible. Otherwise, incision and drainage, with a good chance of permanent cure, must be carried out.

Actinomycosis of the abdominal wall is almost always secondary to an infection of the intestinal canal. It is more commonly found in the region of the cecum. It may be found about the umbilicus or in the flanks. A tumor of slow growth, with irregular and uncertain borders spreading over a considerable area, is characteristic. Involvement of the skin comes late, when the process advances and ulceration takes place. The fistulæ that result resemble those of tuberculosis, but careful and repeated examination of the secretions will reveal the characteristic fungi. Unless there is a secondary infection the neighboring lymph-nodes are not enlarged, but infection of the overlying wall easily takes place from the lumen of the intestine.

The *diagnosis* is made from the history of an intra-abdominal tumor, with symptoms of intestinal infection, late involvement of the abdominal wall, and, after the fistulous stage, the presence of a thin, dirty discharge containing the characteristic gray or yellow granules.

The *treatment* consists in free incision or excision where possible; the laying open and thorough curetting of all fistulæ and infected areas, and the local and internal administration of iodin in some form.

To radically remove the source of the infection may demand serious or even unjustifiable operation. In such cases a thorough course of treatment with potassium iodid, or with copper salts, may be required as a preliminary step.

DISEASES OF THE URACHUS.

In early fetal life the urachus connects the bladder with the allantois. In normal cases, however, by the fifth month its lumen has become obliterated and its presence is represented by a fine cord. But like all transitory organs, it leaves debris in the process of retrogradation which may play a pathologic rôle later on. In the early stages, together with the urinary bladder, it is completely surrounded by peritoneum, which anteriorly forms a mesocyst. The persistence of the latter will explain the intra-abdominal cysts of urachal origin. Furthermore, the lumen of the urachus may become obliterated only in part, and we will find various types of fistulæ—those which open through the umbilicus (external), others which open into the fundus of the bladder (internal),

or which open at both ends (complete). If an intermediate portion fails to become obliterated we will find small cysts which may never give any clinical evidence of their existence. The latter are quite common; large cysts are extremely rare. An incomplete fistula may become complete by the destruction of the blind end, or a retention cyst may become a fistula for the same reason. Recent investigations of Luschka, Wutz, and others show that some degree of patency is present in a very large percentage of cases. The opening into the bladder may be seen as a dimple or as a fine canal capable of being sounded.

The structure of the urachus corresponds to that of the bladder; it has a muscular and mucous wall in the center of which there may be remains of the primitive cavity. The mucous tissue on section recalls that of the bladder, and the longitudinal muscular fibers are continuous with the muscular fibers of the bladder. In the distended cysts these various layers may be more or less blended. In addition to the small, persistent remains of the central cavity we may find diverticulæ which become isolated from the central canal to form cysts.

Larger **central cysts** may communicate with the bladder through a minute opening which may be seen through the cystoscope and entered with a sound. Where a cyst communicates with the bladder it is easily seen how an inflammation may extend upward. Cases have been reported in which urinary calculi have formed in the urachal canal, and the rare instances of the passage of biliary calculi from the bladder can be explained by the inflammatory rupture of a gall-bladder into a patent urachus which has acted as a passage for the gall-stones. It is also possible for a bladder to become infected through a complete urachal fistula. Urachal fistulæ, although congenital, may not become evident until long after birth, when they appear as a result of some inflammatory process in the abdominal wall, the bladder, or the urachal tube itself. Backward pressure of an over-distended bladder may break open the blind end of an incomplete to form a complete fistula. Thus, we may see a sudden gush of urine from the umbilicus after prolonged retention. Fistulæ are more common in males than in females and may be found at any time of life.

Malignant tumors have rarely been reported as originating in the urachus. *Large extra-peritoneal cysts* definitely originating in the urachus are rare. Delore and Cotte could find only 10 cases capable of confirmation. These tumors contain fluid that is pale yellow or brownish from hemorrhage, fibrin, or pus. If there is communication with the bladder, the contents may be ammoniacal. The cysts that become intraperitoneal because of the persistence of the mesocyst may attain enormous size.

Diagnosis.—The diagnosis of minute cysts is rarely made because of the absence of symptoms. The external fistulæ are recognized by the discharge of thin, yellow, or bloody fluid, or of fluid containing urinary elements. Some internal fistulæ may be recognized by the cystoscope, or by the presence of a tumor above the bladder that can

be emptied into the latter organ. At operation the cysts are recognized by their situation anterior to the peritoneum, and by the connection with the urachal cord above or below. The intra-abdominal cysts may be recognized by the pedicle-like connection with the anterior wall and the lack of association with the abdominal viscera. Practically, a differential diagnosis is at times impossible. Encysted collections of peritoneal exudate, septic or tuberculous, and adherent ovarian cysts have been described as urachal cysts. Tuberculosis of the urachus is so rare that the cases reported as such are much more likely to be encysted tuberculous peritonitis.

Examination of the cyst wall will show the presence of characteristic mucous and muscular layers, and the absence of the glands of Lieberkühn will differentiate such growths from those which originate in the vitelline canal.

Treatment.—The treatment of the fistulæ or of the cysts is surgical. It is best to dissect out the cysts, if possible, to open or preferably to dissect out the fistulous canal, inverting the lower stump into the bladder. The intraperitoneal cyst is removed by clamping and ligating its pedicle. At times it may be possible only to open and pack a fistulous tract after curetting away its lining membrane, allowing the wound to close by granulation. In the simpler, internal fistulæ, relief or cure may follow removal of urinary obstruction, that is, by circumcision, urethrotomy, prostatectomy, lithotomy, etc. It is a mistake to close the upper end of a fistula and leave the lower end in direct communication with the bladder because of the liability of a secondary retrograde infection.

DISEASES OF THE UMBILICUS.

Fistulæ, Cysts.—Failure in the complete involution of the vitelline duct accounts for a number of interesting conditions found at the umbilicus. Where the lumen persists throughout we find a fistula, varying in size from a minute canal that allows the escape of mucus or gas, to a wide tube from which the intestinal contents escape freely. If the inner portion remains patent we find the so-called Meckel's diverticulum. If the external and internal openings are both closed a cyst lined with intestinal mucous membrane results, while if the inner end closes a blind fistula secreting mucus and lined with mucous membrane is found. The latter form is often designated as an *entero-teratoma*. It must be differentiated from the persisting urachal fistula by the type of its lining mucous membrane. It also must be carefully distinguished from the granuloma that forms soon after separation of the umbilical cord, because its careless excision may open the peritoneal cavity, or even the underlying loop of intestine with which it originally communicated. The cysts that form are rare, but they occasionally attain considerable size. Tillmans and others have reported a cyst in this region containing a layer of gastric epithelium.

The **treatment** of an enteroteratoma is either complete, and careful removal of its mucous membrane, with ligation of its base, or, what is

safer, a careful excision of the everted tissues and closure of the parietal opening, if this still persists. The lining wall of a cyst must be entirely removed to prevent recurrence. It may be dissected out or destroyed with the sharp spoon or cautery, and allowed to close by granulation.

As the complete fistulæ are likely to be complicated by hernia, a careful dissection, invagination of the intestinal end of the persistent duct, and herniotomy are required. Access to the peritoneal cavity is best obtained by an incision below or to one side of the umbilicus. In this way the exact relation of the gut to the duct can be determined, and the intraperitoneal work can be carried on with the least danger of soiling the cavity. The minute fistulous tracts can be closed by destruction of their lining canal, operation for repair of the open ring being postponed until the child is better able to undergo an abdominal operation.

The hernias that form in connection with the vitelline duct will be treated in detail in the chapter on Hernia.

The umbilicus, owing to the complex structures that enter into its formation, may be the seat of most varied pathologic lesions.

Inflammation, due almost always to uncleanliness, to the retention of foreign particles, sweat, or sebaceous material, may cause most offensive abscesses and ulcerations. Infection may easily invade the neighboring subcutaneous fat or the properitoneal tissues. Inspissated material may collect within its folds to form concretions. The treatment is by free incision, cleansing washes, or even excision. Fistulæ of most varied types are found here. Any of the internal viscera may discharge their contents through this, the thinnest portion of the abdominal wall. Thus we see biliary, urinary, fecal, and gastric fistulæ. Occasionally, a purulent or a tuberculous peritonitis may discharge in this way. Abdomens tensely distended by ascitic accumulations may rupture at the umbilicus and discharge spontaneously. The treatment and prognosis of these fistulæ is dependent upon their origin, the fistulæ themselves being purely subsidiary.

Tumors.—The simplest form of tumor of the umbilicus is the *granuloma*, found soon after separation of the cord. It appears as a bright red, fungus-like tumor, easily bleeding, usually sessile, or later pushing forth and becoming pedunculated. It is more or less bathed in pus, and its surface must be distinguished as formed by granulation tissue and not by mucous membrane, in order that it may be differentiated from the enteroteratoma described above. Usually the size of a pea or bean, it may under chronic irritation form a tumor of considerable size. Sometimes the granuloma becomes covered with epidermis, and later it may appear as a harmless pedunculated tumor of the umbilicus. Granulomata should be cauterized or excised and the base kept clean with mild washes.

Papillomata may be found here, sessile or pedunculated. Although primarily benign, they are liable to degenerate and become malignant, and for that reason should be excised early. They are usually found in the uncleanly.

Gumma at the umbilicus will be attended by other specific lesions elsewhere. If ulceration and induration take place, it may be mistaken for a malignant growth. **Horns** are occasionally found here also.

Of the connective-tissue tumors **sarcoma** is the least rare. It is apt to come in women, remains local for some time, and can be radically removed if operated upon early.

Von Winkel has collected a few cases of teleangiectatic myxosarcoma.

Lipoma is rare. **Myxoma** has been seen.

It is not surprising that **dermoids** and **atheromata** should be found in this region. They may grow to a considerable size, requiring extensive dissection and plastic repair. If they become septic they are best opened and drained at a preliminary operation, and later excised.

Epithelial growths may be found here as elsewhere. With the typic, ulcerating base, they become rapidly foul and offensive, and are easily mistaken for an inflammatory ulcer. A **papillomatous carcinoma** may also form in the umbilicus, probably starting in the benign papilloma.

According to Steinthal, there is a rapidly growing scirrhous form, which breaks down slowly, and forms metastases in the mesentery and lymph nodes, while the two preceding types form metastases in the lymph nodes only. The prognosis of the various forms of carcinoma is not different than for those elsewhere in the body.

More frequent than primary carcinoma of the navel is the secondary form, originating in some one of the intra-abdominal organs, especially the stomach, intestine, or liver, or occasionally in the pelvis. Continuation direct or by the lymphatics from the internal growth explains the origin of these cases. The prognosis and treatment depend upon that of the organ primarily involved.

MUSCULAR RUPTURES.

Rupture of a parietal muscle may take place from external violence or spontaneously from sudden contraction, even in the healthy. Complete tears are rare. The rectus is the favorite seat of rupture; rarely so, the obliques.

Patients debilitated by *typhoid* or other wasting disease can rupture a muscle by such slight exertion as sitting up in bed, coughing, etc. The typhoid ruptures are quite prone to abscess formation. The symptoms are sudden sharp pain, local tenderness, and even vomiting. We may find a depression in the course of the fibers, and later, ecchymosis and swelling. Recovery is usually spontaneous, it being rarely necessary to resort to suture. A tender painful area may persist for a long period and interfere with certain motions of the body.

INJURIES OF THE ABDOMINAL WALL, CONTUSIONS, ETC.

The importance of injuries to the abdominal wall depends, in the main, on the damage inflicted upon the underlying viscera or upon

the peritoneal lining. Contusions, incised and lacerated wounds, limited to the wall itself, call for no special consideration here beyond the fact that intra-abdominal injury must always be considered, and any local treatment must necessarily be based on definite evidence that the injury is confined to the parietes. Wounds that destroy motor nerves or muscular continuity are liable to be followed by some degree of protrusion or deformity. **Burns** of the abdominal wall are always serious, both primarily and secondarily. In the latter case deformity with curvature of the spine is a cause of late discomfort and suffering. The infections that follow injury have been considered above.

That **epigastric hernia** may result from a blow or other injury to the wall, is accepted by some surgeons, but as stated in dealing with the lipomata of this region, Lothrop has been unable to find an authentic case of a hernia produced primarily by injury. In such cases where a hernia is observed after a strain, contusion, or similar injury, the hernial opening in all probability pre-existed. That protrusions may take place through subcutaneous lacerations of the parietal layers is true, but these are not hernias in the strict sense of the word. Bilfinger designates these as "herniæ on a traumatic basis." Coley states of hernias in general that they are not caused or produced by trauma unless there is a direct, heavy force applied at the site of rupture. On this basis extremely few examples of any type of hernia caused by injury to the abdomen have been recorded. As anything more than an indirect or secondary causation, traumatism must be disregarded except in the rarest instances.

Contusions.—In severe contusions muscular attachments may be torn loose without visceral injury. Eisendrath has reported such a case that recovered after suture.

As indicated above, contusions and non-penetrating wounds of the abdomen are important because of the result on the intra-abdominal viscera. Such contusions come from blunt injuries, from falls, from compression between heavy objects, and from a localized trauma inflicted upon a circumscribed area. The body, the wounding object, or both may be in motion. The type of injury depends much upon the angle of impaction, whether it be glancing, oblique, or direct. The tension of the belly muscles at the time of injury governs its effects. A blow inflicted upon an abdomen with tense, expectant muscles will do relatively much less damage than the same blow upon a lax abdomen. In fact, in the first instance, the force must be severe and crushing in order to injure the viscera. In elderly people with weak abdominal and visceral muscles, a very slight injury suffices to produce a visceral rupture. Males between twenty and fifty years of age are most apt to receive these severe injuries, while in females we find them during childhood.

Patients with hernia or with the intestines firmly fixed by adhesions are predisposed to this type of lesion. In addition to the fact that visceral injuries may follow abdominal contusions, they may be produced by falls from heights when the patient lands upright, the organs

being torn from their attachments or, very rarely, a loop of gut may be torn from its fixed attachment by a severe blow on the back, the patient generally, but not necessarily, falling forward upon the abdomen.

Finally, it is possible that spontaneous rupture may attend a sudden exertion which increases intra-abdominal tension; in such instances one of the hollow organs is in all probability overdistended by gas on the proximal side of some form of constriction.

Perez, in a long series of experiments on animals, showed that slight blows cause an ecchymosis of the gut; that less force is necessary with relaxed walls, and that the more circumscribed the force the greater the damage.

A stomach or intestine distended with food, or the bladder with urine, is more easily ruptured than if empty.

The usual sources of injury are horse kicks, blows from fragments of wood thrown by circular saws, blows from wagon poles, from fists, etc.; crushing by wagon wheels or between heavy objects, felling blows by heavy objects like trees, casks, or embankments which do not crush the patient. A patient running and striking the abdomen against the corner of a table or a post may suffer internal rupture.

In direct blows the injury to the hollow organs is usually caused by compression between the striking object and some bone, as the spine or the ilium. Here we may find two lesions opposite to each other in the same coil of gut, and they may approximate the shape of the impinging object, such as the calk of a horseshoe, etc. Direct blows striking upon a coil distended with gas or fluid, especially if the contents are confined by any form of constriction, as in a hernia, above a stricture or rigid adhesions, will produce a rupture by bursting from within. Oblique, and occasionally direct blows, tear the gut by overstretching it in its long axis, or they will tear it from its mesenteric attachment, or from a portion that is normally or pathologically fixed, the location of the injury depending in these cases somewhat on the angle of impaction. In diffuse impaction, as when the abdomen strikes a broad, flat surface, the lesions may be caused by direct contusion, by bursting, or by the tearing of an attachment. In vertical falls and probably in blows from behind, the heavy solid organs or the loaded intestine are forcibly torn from their attachments, the tear invading the lumen or not, as the case may be. The stomach is rarely ruptured by a force that would rupture the intestine. The lesser curvature is the place of choice and ruptures are most liable to be of the bursting type.

The majority of ruptures come in the upper or lower, that is, the less movable portions of the small intestine. For the same reason the cecum and ascending colon are the usual seats of rupture in the large intestine. The free, rather than the mesenteric border, gives way.

Ruptures may be single, multiple, partial, or mixed. Two complete tears may lie near each other with intervening healthy gut. Near a complete tear we may find incipient tears—thus, the mucous coat alone may be destroyed or, in bursting tears, the peritoneal coat. Con-

tusions or incomplete tears may be eventually as serious as complete tears. Complete tears, embracing the circumference of the gut area are usually found at the junction of a movable with a fixed portion. In the bursting types the different coats are unequally torn, the peritoneal suffering most. The edges of a contusion-rupture may be sharp, ragged, or everted. Bursting ruptures are usually slit-like. The infiltration and hemorrhagic area that extends beyond an opening may later become necrotic. Partial ruptures that appear harmless at the time of injury may break down at the end of days, or they may contract and form serious constrictions at the end of months or years. When only the inner coat is destroyed it may be passed in the stools at a later period.

Contusions or tears of the mesentery may produce serious immediate hemorrhage, or later necrosis of the gut from interference with its blood supply.

The intestinal contents may pour forth at once, especially if they are liquid, or this may be impeded by the eversion of the mucous membrane. A small tear will be temporarily sealed by adhesions, only to be reopened with the establishment of normal peristalsis, pressure from gases, etc. Gas escaping into the general cavity may modify the percussion note. If the gut empties into the extraperitoneal tissues, we may expect infection and emphysema of the cellular tissues. Peritonitis will follow injury to the intestines at once or after a longer period, varying with the type of injury. A tear involving only the inner coats may result in the passage of blood at stools. Enough cases of appendicitis following injury have been reported to definitely establish the relation of cause and effect.

Any of the solid organs may be ruptured, though less often than the intestine; the liver and spleen being more commonly injured than the pancreas or kidneys. An organ softened by disease is more easily torn than a normal one. The gall-bladder may be ruptured by severe contusion, and if the bile is sterile, the peritoneum proves itself very tolerant, sometimes allowing its presence for days or weeks.

Hemorrhage or extravasation from the kidneys may be limited to the retroperitoneal tissue, or in case the overlying peritoneum is broken, it may pour forth into the general cavity.

The pancreas is rarely injured. Dos Santos has recently summarized the cases reported in literature, and shows that hemorrhage may take place into the retroperitoneal tissue or into the omental bursa; that fat necrosis may take place and occasionally will disappear spontaneously; that fistulæ, scar contraction, or cysts may follow secondarily. When the contusion has been severe enough to produce necrosis of the abdominal wall we may find a hernial protrusion as a result. The diaphragm may be ruptured, allowing the intestines to herniate into the pleural cavity. The bladder may be torn into the general cavity or into the perivesical tissues, and, in case of crushing injuries, we will usually find a concomitant fracture of the pelvis. Any of the larger parietal or intra-abdominal vessels may be ruptured, followed by severe or fatal hemorrhage or aneurysm. Rarely openings may be formed in the

omentum or mesentery, through which the gut may protrude and become strangulated.

Symptoms.—The symptoms in contusion of the abdomen are shock, vomiting, shallow thoracic respiration, pain, and rapid pulse. These may all be present in contusions with existing visceral injury and in contusions without visceral injury. It is often absolutely impossible to determine in the early period following trauma, at the time when surgical interference is indispensable, whether an abdominal organ is seriously damaged or not without deliberately exploring the abdomen. Bottomley, analyzing an equal number of cases with and without undoubted visceral injury, found that shock, pain, and vomiting varied in individuals in the early hours after injury. If vomiting persisted or recurred after a temporary cessation it should be regarded as serious evidence. Definite conclusions with regard to shock cannot be drawn. So may it be said of muscular spasm and tenderness. If these come late we may infer that the lesion is serious. According to Crile, the solar plexus may be disregarded as a factor in the various phenomena that attend abdominal contusions. The symptoms are rather the result of the trauma on the heart and its nervous mechanism.

According to Bottomley, there is no sign or combination of signs sufficiently constant to indicate the nature of the injury or to serve as a basis for diagnosis. Exploration is the only definite means that we have for making a diagnosis in season for effective treatment. To wait for definite intraperitoneal signs is to wait too long, and we must not be deceived into a false security by an improvement in the early symptoms. This may come with reaction from shock even in the worst types of injury, and it should not lead us to hesitate in advising exploration. Le Conte lays stress on the facial expression and on deep radiating pain. Immediate vomiting is not necessarily significant as regards internal injury, but if it persistently recurs, it is of the greatest significance. An increasing spasm and tenderness most surely point to peritoneal infection. If not limited to the point of contusion in the early stages, Mauclaire and Roger believe that it is very significant of grave lesions. To depend upon the extent of liver dulness and evidences of fluid in the flanks is a waste of valuable time. Perez lays great stress on the value of continuous superficial and rapid respiration. An increasing pulse rate is an important sign, but in hemorrhage without extravasation of intestinal contents it must be again emphasized that for several hours a slow pulse may attend an abdomen full of blood, after which a sudden and serious collapse takes place, especially if the cavity is opened.

In partial rupture of the intestine the early symptoms are similar to those that attend a severe contusion. These may subside for the most part, except that moderate local pain and tenderness will persist. Later, if the necrosis is complete, there will be a sudden outburst of peritonitic symptoms due to the intestinal extravasation. If the necrosis is confined to the inner coats we may expect early tenderness and melena, with symptoms of obstruction after a space of months

or years. In traumatic hernia through the diaphragm we may expect tympany in the pleural cavity, signs of intestinal strangulation, rapid respiration, hiccough, etc. In rupture of the bladder there is pain and tenderness, evidence of fluid in the abdominal cavity, and blood with insufficient urine obtained by catheter.

The mortality in a severe injury of the intestines under expectant treatment is almost 100 per cent.

Severe injuries of the solid organs are almost always fatal from hemorrhage, abscess, or extravasation. Slight parenchymal ruptures may heal spontaneously with the formation of extensive adhesions. Slighter injuries may ultimately cause death by the formation of constrictions, adhesions, etc. Simple contusions, if severe but without visceral lesion, may cause death by shock. Visceral ecchymoses may result in thrombosis, local necrosis, and infection. It is very doubtful if contusions are followed by malignant degeneration. The retroperitoneal sarcomata may be started in this way, but that cancer of the intestine and stomach may be secondary to acute traumatism is extremely doubtful.

Treatment.—The treatment, as indicated above, is surgical, best within a few hours after the receipt of injury. In case of the least doubt an aseptic exploration is vastly safer than delay until definite evidences of damage are forthcoming. The external signs of injury, especially in diffuse blows, may be wanting; if, on the other hand, there are superficial marks of contusion, it is wise to explore in that neighborhood, wherever it may be. Intestinal suture or resection, suture or packing of the rent in a solid organ, splenectomy, nephrectomy, partial excision of the liver, pancreas, or kidney may be called for. In closing intestinal rents it is well to excise rough edges or contused areas to prevent secondary necrosis. Discolored areas in the gut must be treated as possible areas of necrosis. Wide excisions may be called for in injuries to the mesentery. Rupture of the diaphragm calls for laparotomy, thoracotomy, or both, with reduction of the viscera and suture of the rent. A rent in the bladder may be closed in layers, or, if extraperitoneal, it may be necessary to drain both the bladder and the infiltrated tissues.

Penetrating Wounds.—Penetrating wounds of the abdomen may be divided roughly into three classes: stab, gunshot, and impaling wounds. It is safer to regard every penetrating as a perforating wound as far as treatment is concerned.

Stab wounds are less serious in the upper than in the lower abdomen. In about 50 per cent. of penetrating stab wounds there is prolapse of the omentum or, more rarely, of the small intestine. It may come at once after injury or it may be caused by coughing, vomiting, or straining. A large majority of stab wounds are less than 4 cm. in length, and Finkelstein has shown that in about 60 per cent. of cases the internal organs escape injury. The liver, intestine, diaphragm, stomach, and spleen were injured in his cases in that order of frequency. Death from hemorrhage or peritonitis is to be feared most. There is

no way of telling from outside appearances or from general symptoms the amount of internal damage done. Blood in the vomitus, urine, or stools is an important indication if present. The safest treatment for a stab wound that penetrates, or which is suspected of penetration, is early careful exploration.

Gunshot wounds are more serious, and the mortality, especially in civil life, is greater than in stab wounds, in the former case it being at least 70 per cent., in the latter about 25 per cent. Gunshot wounds are more likely to involve the intestine and to be multiple. Wounds from in front are less serious than those from the side. The size of the wound does not determine the size of the bullet necessarily, the question of the angle of impaction and the bursting force being factors in this respect. The mortality in modern war is less than in civil life. Treves' estimate of 40 per cent. mortality without operation in the Boer War is probably too low, as it does not take into account those who died in the field or during transportation to the hospital. About 90 per cent. of gunshot wounds perforate some organ or organs, a good half being of the intestinal tract. Closure of an opening by mucous membrane is rare, there being almost always some escape of the intestinal contents. Wounds in the upper abdomen, whether stab or gunshot, are less to be feared than in the lower abdomen. The experience at the Charity Hospital, New Orleans, according to Fenner, shows that wounds in the former region may be treated more conservatively if there is good evidence of no active intra-abdominal injury. Even in time of war there are no data that determine that immediate surgical treatment under proper conditions, were such conditions obtainable, is not better in the long run than conservative treatment. Lacking proper conditions, however, it is probably safer to carry out conservatism than to undertake radical steps in the presence of dirt, insufficient surgical and nursing care, etc. Rodman maintains that immediate operation should be done if a competent abdominal surgeon and aseptic surroundings are available, but on the battlefield or under similar conditions in civil life he would take his chances without operation, relying upon abstention from food and drink and the use of opium.

That penetrating wounds of the gastro-intestinal tract do heal spontaneously, especially in the upper segments, if empty at time of injury, is well recognized, but under favorable surgical surroundings no one at the present time could assert that the chances were not greatly improved by timely operative interference. The interval of time that elapses between injury and intervention bears a most important relation to the prognosis. Of over 700 cases collected by Siegel, the mortality varied from 15 per cent. in those operated upon within the first four hours, to 87 per cent. where operation was delayed beyond twelve hours after injury. Hemorrhage and peritonitis are the main causes of death, neither of which brooks delay. Bullet wounds usually perforate both walls of the hollow viscera; stab wounds may do so. In either case careful search should be made with this possibility in view. A bullet's track through the soft abdominal organs may be most erratic,

and no definite conclusions can be drawn from the line of its course through the parietes. Early favorable symptoms after a gunshot wound may be followed by sudden fatal collapse due to gangrene that results from a contused gut, mesentery, or solid organ.

Treatment.—Repair of gastric or intestinal wounds by suture or excision will be called for. Rarely will enterostomy be necessary. Wounds of the solid organs may be sutured or packed or the organ in part or whole may demand excision. Mesenteric wounds may require intestinal resection. Wounds of the bladder may require suture or partial excision with perineal drainage. Ureteral wounds may require nephrectomy. It is safer, as a rule, to drain an abdomen after gunshot wounds, if only for a few days, as the amount of infectious material that is transported with the missile or that escapes at time of perforation cannot be estimated, and often cannot be properly removed at the operation.

Impaling wounds are generally the result of a fall upon the end of a stake or picket, which enters by the perineal region. It may traverse the parietes lengthwise without penetrating the peritoneum, or the latter may be punctured at any place in its course, even in the upper abdomen. When penetration takes place there will usually follow a prolapse of the viscera, and the latter may be injured by direct compression between the impaling object and the bony walls or by forced traction from their attachments. Exploration must be carried to the utmost limits of the wound, lest a penetration be overlooked. If only the parietal wall is injured the tract must be thoroughly cleansed and drained with a fair chance of success. If the cavity is entered, the prognosis depends on the nature and extent of the visceral injury. Not infrequently the scrotum and its contents are severely mutilated. Similar wounds occasionally result from the horns of cattle.

Perforating wounds of the viscera may take place from within by the passage of sharp objects, such as bones, nails, pins, etc., or by forcible puncture with instruments or foreign bodies passed into the stomach, bladder, uterus, or rectum. In the former case the perforation may be gradual and productive of slight symptoms, as when needles penetrate the parietes from the stomach or intestine. At other times a parietal abscess followed by a fistula may be caused by infection from the lumen of the gut, or a severe or fatal peritonitis may be started by the penetrating object. In any case an exploration is the only rational treatment. The diagnosis may be impossible without operation. In suspected cases the *x*-ray may demonstrate the presence of foreign bodies.

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CHAPTER XLVII.

SURGERY OF THE PERITONEUM AND THE RETROPERITONEAL SPACE.

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ANATOMY OF THE PERITONEUM.

The peritoneal cavity extends from the under surface of the diaphragm above to the pelvic floor below, being bounded laterally by the parietes. It contains the various viscera, all in more or less intimate relation with the peritoneal lining. Some, like the liver, are held in comparative fixation by short reduplications of the peritoneum and subperitoneal tissues. Others, like the pancreas and terminal portions of the duodenum, are held in place against the posterior wall by the sweep of peritoneum that stretches over their anterior surface. Others, like the kidneys, have a thick layer of fat and connective tissue imposed between the overlying peritoneum and themselves. Still others are, so to speak, swung more or less freely in peritoneal folds. The latter are classed as intraperitoneal organs, a term that is convenient clinically, but which is anatomically incorrect. They are intra-abdominal organs, but, strictly speaking, retroperitoneal and not intraperitoneal. Such are the stomach, intestines (major portion), spleen, and female pelvic organs. The total area of the peritoneal lining nearly equals that of the skin.

The peritoneum itself secretes a colorless fluid sufficient in normal conditions to lubricate the many surfaces of the intestines and other viscera. Under conditions of irritation or of inflammation this fluid may be secreted rapidly to the amount of many pints, and, as will be seen when considering peritonitis, the character of the fluid rapidly changes from a clear serum to a cloudy, fibrinous, purulent, bloody, or chylous exudate, more than one type being present in most cases. Equal to the ability of the peritoneum to secrete fluid is its ability to absorb fluid and minute foreign particles. Most of this absorption takes place in the upper peritoneal surfaces (diaphragm and omentum), a fact that is of great value in the treatment of infections of the peritoneal cavity by position, rapid and fatal absorption of toxic products taking place when the upper portion of the cavity is bathed in septic intra-abdominal fluids, while relatively insignificant absorption takes place in similar cases if the patient is placed with the head and trunk elevated (so-called Fowler's position, see Fig. 386) or in the sitting position.

The lymphatics of the abdomen in relation to the individual organs are most important, and they must be considered in detail in the chap-

ters dealing with the various visceral diseases. A full account may be found in Poirier and Cunéo's "Lymphatics." In a general way, it will be necessary to consider here only the various groups of lymph nodes. In the pelvis there are three main paravascular groups, located alongside the iliac vessels as high as the aortic bifurcation. These glands, roughly speaking, are supplied from the superficial inguinal region, the external genitals, bladder, prostate, seminal vesicles, and uterus; from the deep umbilical and, to some extent, from the hemorrhoidal region. In addition to these glands, we may find a few along the course of the deep epigastric and the circumflex iliac arteries. Above the bifurcation of the aorta we find the abdomino-aortic glands, twenty or thirty in number, grouped around the aorta. These glands lie in the path of the lymphatic current coming from the pelvic glands, and receive in addition lymph from the abdominal muscles, the testis, ovary and uterus, kidney, and adrenal. The lymph from the genital organs passes to the glands lying anterior to the vena cava. The chain of glands lying close to and anterior to the aorta tend to group themselves about the three main visceral trunks and receive their supply from the corresponding viscera (intestine, stomach, liver, pancreas, and spleen). In addition, there are glands scattered throughout the mesentery, while along the celiac branches there are glands connected with the coronary, the splenic, and the hepatic vessels. Each one of these groups should be studied in detail. Posterior to the aorta are a few glands which Poirier and Cunéo designate as "a fresh relay interposed between the preceding groups and the receptaculum chyli."

In the course of development of the abdominal viscera various folds and fossæ are formed, the possible seat of internal herniæ. The nomenclature of their fossæ is at the present time very confusing and complex, so that no attempt can be made here to settle so intricate a problem. In all classifications, however, it should be borne in mind that numerous peritoneal anomalies are constantly seen by the surgeon at operation, anomalies that are undoubtedly congenital and not pathologic. Until these anomalies can be more thoroughly studied it will be best for the operating surgeon to consider the locations only in general, regarding slight variations as variations that are consistent with any developmental anomaly. To Moynihan's "Treatise on Retroperitoneal Hernia," I am indebted for the main points. First of all, there are folds and fossæ in the region of the duodenojejunal junction, and whether to one or another side of the gut, this is the most common location for retroperitoneal hernia. Then we find folds and fossæ of various types in the ileocecal region which serve as portals for herniæ. An intersigmoid fossa seen to the left and below the sigmoid mesocolon, as well as the foramen of Winslow, may allow the gut to escape into a retroperitoneal pocket.

Views on the *sensibility of the peritoneum* in various regions differ greatly among observers. Lennander, after long and careful experimental observations, has shown that the parietal peritoneum is very sensitive, but that the peritoneum of the stomach, mesentery, great

omentum, anterior portion of the liver, gall-bladder, urinary bladder, uterus, ovary, and intestine, is completely insensitive for all operative attack. Moreover, the peritoneal regions which lack feeling in health, lack it equally when inflamed. Previous to this, Cushing had shown that portions of the peritoneum insensitive in health are also insensitive when inflamed. To gain anatomic light on this problem, Ramström has recently conducted elaborate dissections, and has shown that the intercostal and lumbar nerves supply the anterior parietal peritoneum. The nerves ramify repeatedly in the peritoneum, and pass upward, downward, and laterally, whereby net and loop formations are found in the subserosa as well as in the serosa. His researches show, moreover, that the phrenic nerve has nothing to do with the innervation of the anterior wall, the intercostals supplying not only the anterior wall but also the portion of the diaphragm along the costal margin.

TUMORS OF THE PERITONEUM.

Tumors of any type, that start primarily in the peritoneum, are very rare. **Benign tumors** are found most commonly in the mesentery or the omentum, and many of these, as a matter of fact, originate in the underlying tissues. Echinococcus is rare. It is seen as solitary cysts, generally in the omentum or mesentery, and being free to expand, it may form a large tumor. When secondary it is found as small, diffuse, and multiple cysts. Lipoma, appearing as the pure type, as fibro-lipoma or with myxomatous degeneration, is rare. When appearing in the mesentery or omentum it is probable that the origin is retro-peritoneal. Coming in the anterior wall, lipomata start in the tissues adjacent to the peritoneum, pushing the latter ahead and forming tumors of considerable size. The fibrous types, as elsewhere, tend to degenerate to malignant growths. Sometimes they contain chalky deposits. Fibromata may appear as small projecting nodules on the gut or on the parietes, rarely attaining any important size.

Cystic tumors are more common than solid tumors, and are seen in the mesentery and omentum. The simplest are the blood cysts which may come from trauma, from hemorrhage into a pre-existing cyst, or from hemorrhage into a softened, solid tumor. Chylous, dermoid, or serous cysts are retroperitoneal in origin and are considered elsewhere. Rarely may an encapsulated abscess form a cyst. Angiomata and enchondromata are very rare.

The symptoms of benign tumors are secondary to the mechanical effects, varying with their size, location, etc. The diagnosis is difficult. The association of digestive disturbances with a tumor that feels solid or cystic is the first step in determining their nature. Mesenteric cysts lie on the right and below the umbilicus, unless they are situated in the mesentery of the upper jejunum or in that of the sigmoid, when they will lie above the umbilicus, or below, and to the left respectively. Their nature and location can be determined definitely only on exploratory laparotomy.

Malignant tumors of the peritoneum are very rarely primary. The secondary tumors arise by direct invasion or by metastasis. Cancer of the stomach is the most frequent source, but the primary growth may be in such organs as the gall-bladder, rectum, uterus, breast, etc. Peritoneal carcinoma may appear as part of an acute general carcinosis, when it is manifested by miliary nodules, which may be mistaken for tuberculous nodules. The former, however, are larger, less translucent, lighter in tint, and without caseation. The tendency of the infected areas is to form adhesions and to contract. We rarely see a dry peritoneum in these cases, an exudate varying from a clear yellow to a bright red (hemorrhagic) color being much more common. A purulent exudate indicates some form of secondary infection; some writers have reported exudates that were chylous. An exudate may be encapsulated, but this has rarely been observed in my own experience. The clinical picture of a carcinomatous peritonitis is so much like that of a tuberculous peritonitis that it may be difficult to distinguish between the two. The disturbances in the visceral functions, the tumors palpable on examination, meteorism, vomiting, evidences of free fluid, etc., are common to both diseases. In tuberculosis, however, there is very constantly some irregularity in temperature, which is comparatively rare in carcinoma, although in the latter we may find some fever in both the general carcinosis types as well as in the secondary infections. Cancer is more apt to occur after puberty and cachexia is apparent early in its course. In exceptional instances an acute carcinomatous invasion may simulate an acute infectious disease with its fever, delirium, and rapid onset. The recognition of a primary malignant focus or of a characteristic adenitis will materially aid us in determining the presence of peritoneal carcinoma. A rapid accumulation of fluid after paracentesis is strong evidence of malignancy.

The *treatment* is symptomatic. Very rarely can a localized tumor be removed, and removal is almost sure to be followed by recurrence.

Sarcomata of various types have been reported as commencing primarily in the peritoneum. When starting in the omentum or mesentery, the tumor may grow to large size. Tillmanns mentions endotheliomata that arise from a proliferation of the endothelial cells of the lymphatic vessels and of the peritoneum itself. They may appear as multiple bands, with nodules, frequently medullary in type. The treatment here is symptomatic, as in carcinoma.

TUBERCULOUS PERITONITIS.

This form of infection is found at any period of life, more commonly before the age of forty, most commonly between thirty and forty. Both sexes are affected about equally, post-mortem data giving a preponderance to the male sex, operative statistics to the female sex. There is apparently some association with concurrent cirrhosis of the liver, but whether as cause or effect is not definitely established. The spleen is apt to be enlarged.

The focus of origin may be near or remote in the lymph nodes, lungs, bones, intestines, etc. Cases in which the disease starts primarily in the peritoneum are so rare that one must question the accuracy of observation.

As the tubercle bacillus exists only in living tissue it does not often destroy its host, the processes which terminate life, according to Mayo, being largely secondary infections. Tuberculosis of the intestinal tract, either primary or secondary, and tuberculosis of the genital tract, especially the Fallopian tubes, account for a considerable share of the cases seen on the operating table. Mayo, in a large experience, found that many cases temporarily benefited by drainage relapsed because of a focus in one or both tubes that actively persisted. In some, removal of the fluid allowed the open tube to collapse and to institute a natural cure by delimiting adhesions, obliterations, and scar formation. If, however, the infecting focus, such as a tube, an appendix, cecum, or mesenteric node could be eliminated at operation, the permanent results would be much better. In other words, if a persistent reinfection of the peritoneum from a definite focus could be prevented spontaneously by adhesion or scar formation or, best of all, by entire excision, a good chance of radical cure could be obtained. Even where focal excision is attended by the temporary persistence of an effusion, reinfection of the peritoneum does not necessarily follow. Very rarely a peritonitis may come from the spontaneous perforation of an intestinal ulcer or from a perforation caused by straining, vomiting, or passage of foreign bodies.

Observation at operations has shown that the peritoneal infection is most marked near the seat of origin. In some the focus cannot be determined; it is probably in some remote organ, such as a bronchial lymph node.

Tuberculous peritonitis may present many appearances, frequently the same patient exhibiting several types. In the acute miliary form, in which the peritoneal involvement is but a part of a general infection, we may find diffuse miliary tubercles with or without manifest signs of inflammation. There may or may not be an exudate. The disease is rapidly fatal and is rarely seen by the operating surgeon. Of the local forms which are more or less suitable for surgical interference, we find the ascitic (acute or chronic), the fibrous, and the ulcerative types. The ascitic, which may be complicated with the other forms, is characterized by fluid, often in large amounts. At the same time there will be areas covered by tubercles of varying size and by fibrin; elsewhere we may find areas of thickened vacularized peritoneum which tend to form adhesions. In advanced cases the process at some portion may have gone on to a formation of ulcers, abscesses, or fistulæ.

In the typic cases of circumscribed tuberculosis, such as is found originating in a Fallopian tube or in the appendix, we will find extending outward in varying degree small tubercles scattered about the adjacent peritoneum. It is difficult or impossible to find the bacilli in the fluid exudate and it may be difficult to detect them in the tubercles.

Wunderlich, in an analysis of 500 cases, found that 68 per cent. were of the exudate type, 27 per cent. were fibro-adhesive, and only 4 per cent. suppurative.

Diagnosis.—The diagnosis in many cases is easy. As a rule we find slight pain, moderate diarrhea where not dependent on intestinal ulcers, moderate fever (though its absence has been noted not infrequently), loss of weight and strength, occasionally pigmentation of the skin. The presence of fluid, free or encapsulated, is to be expected in a majority of cases. In the fibrinous and localized types there will be found masses varying in size from small nodules, single or multiple, to enormous cyst-like or solid irregular tumors. These masses are usually more or less tender. Abnormal areas of dulness and flatness will be found, according to the size and location of these masses of adhesions, which are very rarely movable. In the ascitic forms the area of tympany, according to Thomayer, is more widely distributed on the right side than in other ascitic diseases except cancer, because in the infection and retraction of the mesentery by the tuberculous (or carcinomatous) process the small intestines are drawn more to the right than to the left side of the abdomen, owing to the oblique insertion of the mesentery. This sign, however, is of use only in restricted types. When the omentum becomes infiltrated and contracted, as so frequently happens, it may be felt as a nodular transverse cord-like tumor. In cases with much fluid this tumor can be felt in ballottement. In yet other cases, with very little fluid, but with adhesions not sufficient to form tumors, the abdomen presents an inelastic, boggy feeling, with obscure definition of the deeper landmarks. As in other tuberculous affections, leukocytosis is usually absent.

It is important to make a differential diagnosis between tuberculous peritonitis and many other intra-abdominal lesions. Ulcers or carcinoma of the stomach, infections of the gall-bladder, kidneys, and pelvic viscera may simulate this form of peritonitis. Diffuse intra-abdominal cancer of varied origin and with ascites usually arises after middle life. Cirrhosis of the liver, with serous exudate, is not rarely misinterpreted, and as a cirrhotic liver accompanies tuberculous peritonitis in a small proportion of cases, the evidence of hepatic trouble at operation should suggest the possibility of an accompanying tuberculosis. The ascites that is found in girls at puberty and in the infectious diseases of childhood may be mistaken for a tuberculous ascites. So, also, the so-called idiopathic peritonitis of uncertain origin must be considered here. The presence of a tuberculous focus elsewhere in the body will argue in favor of this lesion in the abdomen. The reaction to tuberculin is too open to error to be of value except in a small proportion of cases. Animal inoculation requires too long delay and, for that matter, the risk to the patient from aspiration is greater than the risk of an aseptic exploration.

The onset is usually slow, but occasionally it may be acute and the condition be mistaken for one of the acute pyogenic infections of the abdomen. In the chronic types the patient loses strength and appetite,

notices enlargement of the abdomen, and in the presence of fever, the case may be regarded as one of mild typhoid. In the cases that progress steadily to ulceration and pus formation the course is rapidly fatal. Patients with the milder exudative types under proper medical, surgical, or combined treatment may live as invalids for months or even years, with a good chance of permanent recovery.

Treatment.—The treatment in the acute miliary, the ulcerative, and the dry, fibrinous types, is essentially non-surgical. In the exudative and encysted types it is both medical and surgical. Under proper climatic treatment a good share of the simpler types are curable. Fenger has stated that 50 per cent. of all cases are curable under medical treatment, but this is often at the expense of much time, invalidism, and money, and he failed to realize that of the remaining 50 per cent. not curable medically, probably one-half could be materially benefited or cured by operation. Ochsner has wisely advised medical treatment at the outset of this disease in general. If progress is not favorable and steady, surgery should be called upon, especially when the infection is, to all intents, confined to the abdomen.

The mere evacuation of serum from the cavity has undoubtedly brought about permanent cure in many instances. This may be explained in cases starting from tubal infection by the collapse and attendant adhesion of the open end of the tube, allowing the infection to localize itself, and preventing a continuous reinfection of the peritoneal cavity. Mayo has shown that such cases develop a local, nodular tuberculosis of the tube-end, which can be detected by palpation or at a second operation, but which was not present at the first drainage operation. This probably accounts for a certain proportion of surgical cures. Other cures are explained in various ways: by a slow dropsical degeneration of the epithelial cells, by a venous hyperemia, by the formation of opsonins, etc. Whatever the theoretic explanation, it seems pretty conclusive that a removal of the infecting focus, whether in the tube, the appendix or cecum, mesenteric nodes or intestinal ulcerations, is a long step in the right direction for permanent cure by operation. Where such a radical step is not advisable, evacuation of the fluid collections augments the effects of the climatic and medical treatment that must be carried on in any case. The milder, favorable cases can be undoubtedly cured medically. It is worth considering seriously whether this good outcome may not be hastened and rendered safer and surer by timely surgical interference. To delay favorable cases that do not yield to medical therapy until the conglomerate, adhesive, or ulcerating conditions are established, is to throw upon surgery one of the most difficult and often hopeless tasks.

Reaccumulation of fluid is not necessarily a contra-indication to repeated operation, but it is in these cases that the experience of the Mayos has shown the wisdom of recognizing and eliminating the local focus.

Rose investigated a considerable number of cases treated medically, and found that although temporarily benefited, they, for the most part,

eventually succumbed, only one-third remaining permanently cured. If we grant that too few cases of radical operation have passed the five-year limit to give comparative data, we must nevertheless be willing to grant that logically the results should show an improvement over a treatment that can only suppress, but cannot eradicate the *fons et origo mali.*

All surgeons agree that drainage must be avoided. The liability to secondary infection, to necrosis of the intestine, and to transplantation infection is too great a risk.

That climatic treatment should be carried out as carefully and strictly as in pulmonary tuberculosis is being more and more recognized. Its importance cannot be emphasized too strongly. Cases operated on, which do not derive benefit from interference, show the evidence of failure quite early, and these cases die usually within a few months. We may reasonably anticipate relief after operation for a year or more in 30 to 40 per cent. of all cases. Modern surgeons report relief of two years or more in 50 per cent., a good share of these being among failures under previous medical treatment. By selection, by early and radical operation when possible, we must look for a considerably larger percentage of cures.

The prognosis in the dry, agglutinating, and in the ulcerating forms, especially with concurrent pyogenic infection, is bad. Neither medicine nor surgery offers much hope. Indeed, surgery had best be ruled out as a therapeutic measure in most cases of these types. In the intestinal types with tuberculous nodes it is best to remove the latter when it can be done safely.

It is unnecessary to elaborate the fact that any treatment is hampered in prognosis by the presence of tuberculous lesions elsewhere in the body, and that no prognosis must be ventured unless a thorough knowledge of the conditions of the lungs, joints, etc., is obtained.

A form of peritonitis, the so-called pseudotuberculous peritonitis, is encountered at rare intervals. Anatomically, the condition resembles a tuberculous peritonitis, but the source of infection, according to Ophüls, may be bacteria or fungi of different forms, small bits of foreign bodies, animal parasites, hydatid hooklets, etc.

FOREIGN BODIES IN THE ABDOMEN.

That foreign bodies, especially sponges, will continue to be left in the abdominal cavity seems likely, so long as surgery continues to be an art and not a mechanical trade. That every surgeon of experience has been the unhappy cause of this accident very few will deny. There is no mechanical system that is infallible to prevent such accidents. Their frequency can be diminished and early recognition of the accident can be facilitated by simplicity in operative technic, system, and watchfulness.

Sponges tend to escape spontaneously through the skin wound and by way of one of the hollow viscera. An aseptic sponge may remain

encapsulated and harmless for weeks, months, or years, or, by mechanical irritation and pressure upon the wall of the intestine or bladder, a secondary infection may be induced, necrosis follow, and the foreign body be extruded into the lumen of the gut. If the foreign body is primarily septic it causes disturbance at once. If it is aseptic and can be destroyed by phagocytes, it may slowly disappear in part or whole, leaving perhaps an area of scar tissue to mark its location.

A foreign body, like a clamp or scissors, may be suddenly forced into a hollow organ by muscular action or a blow, and give rise to sudden symptoms.

The symptoms of a retained foreign body depend upon its sterility, size, shape, and location. A small sterile silk ligature will rarely produce any symptoms; on the other hand, it may be the exciting cause of adhesions, which later develop into constricting bands. If infected, it will form the source of an abscess which is usually the precursor of a sinus. This will persist until the offending body is ejected or removed.

FIG. 385.—A PAIR OF FORCEPS THAT HAD REMAINED IN THE ABDOMINAL CAVITY FOR TEN AND ONE-HALF YEARS. (J. E. Fergusson Stewart.)

With larger bodies, such as a gauze sponge or wick, we are apt to find obscure abdominal pains or symptoms of a mild ileus. The normal progress of the case will not be quite satisfactory. There may be slight fever. The symptoms yield temporarily to rest and diet, but recur as soon as active habits are resumed. Suddenly, at variable periods of time, there is an outburst of symptoms that indicates an active septic process, which is easily interpreted as coming from some independent intra-abdominal infection. These symptoms will demand operation with a disclosure of the true cause, or else they will spontaneously subside and the sponge will be passed by the rectum or through a broken-down scar. Occasionally, a large piece of gauze when left in the abdomen of a patient who has undergone a serious operation will so perpetuate the usual post-operative symptoms that death results.

In the chronic cases a local tumor or at least a local tenderness is frequently found.

The mortality in reported cases, according to Schachner, is nearly 50 per cent. In spite of the fact that a good proportion of these acci-

dents are never reported, we doubt if the mortality is necessarily greater. The tendency in aseptic cases is toward the escape of the foreign body in some way.

Schachner has reported recoveries after the inclusion of various types of objects besides sponges, such as tubes, a clamp, seal ring, fragments of glass, etc. Occasionally, a foreign body that has done no mischief is found after death from some intercurrent disease.

I am not cognizant of any system for preventing this accident that is infallible. I have seen it take place in a dozen or more instances under as many different methods for its prevention. As a rule, coolness and alertness in trying emergencies, uniform methods in assistance and operative technic, avoidance of the use of small sponges or instruments within the cavity, some form of checking the packs or wicks used, in which the surgeon and his corps of assistants are trained, an intelligent sponge count before and after operation, and the elimination of outside distractions, will materially lessen the chances of these unfortunate accidents.

INFLAMMATION AND ABSCESS OF RETROPERITONEAL SPACE.

Infection of the retroperitoneal tissues may come from the kidney or its pelvis, from the pancreas, or from an osteomyelitis of the spine, ribs, or pelvis. It may follow perforation of one of the hollow viscera (ulcer, foreign body, rupture), rupture of a hepatic or splenic abscess. It may be secondary to a peritonitis by direct invasion, though it is much more apt to start as a lymphangitis, secondary to some intraperitoneal focus. A foreign body entering from the outside or from the vagina will carry infection, and a hematoma caused by a blow may become infected and form an abscess. From the thorax an empyema may travel downward to this space or a subphrenic lymphangitis may extend to the lymphatics of this space. Probably, however, the reverse is more likely to be true. Infections originating in the lower extremities or in the pelvis, and invading the lymphatics along the iliac vessels and the aorta, may give rise to retroperitoneal abscesses.

Occasionally, an extensive abscess of this region arises spontaneously so far as can be determined, a metastasis from some distant lesion, a slight local injury sufficient to cause a small necrosis being probably the origin, although a careful post-mortem examination may fail to disclose it. Eliot has reported a case of gangrene of the retroperitoneal fat for which no source could be determined at autopsy. I have recently seen a case of extensive abscess of this space on the left side in which a most careful post-mortem examination failed to disclose the source of infection. In the infections that are found on the right side a careful inquiry into the early history will almost invariably disclose an infection of the appendix as the primary cause. This is easily overlooked at the operation or at the autopsy, because by the time that the retroperitoneal infection is well advanced the appendical evidences may have subsided to such an extent that they can be recognized only on a most careful,

painstaking examination. I believe that emphasis should be placed on this source of infection, because I have seen it overlooked in many instances.

Retroperitoneal infections tend to gravitate downward along the spine or into the perirenal tissues. In the former case they may point in the region of the groin, above or below Poupart's ligament; in the latter they tend to point in the loin. When adjacent to the spine we may find symptoms of indigestion from interference with the intestinal functions, rigidity of the back, referred pains similar to those found in abscesses of the spine, with deep fulness and tenderness, flexion of the thigh, and general signs of infection. In the loin there is always spasm of the quadratus and often a visible fulness.

These infections may vary from a simple adenitis, with more or less periadenitis, to a diffuse, brawny infiltration, or even to a large fluctuating abscess. The first two types are quite analogous to a deep cervical lymphangitis, and free incision and drainage of the infected tissues, even though no pus is forthcoming, will give relief. I have seen a patient with an extensive infiltration of this region (secondary to an appendicitis) which had been regarded as a renal sarcoma at a previous operation and given up as inoperable. These infections when secondary to appendicitis may manifest themselves at the very outset, or they may not develop for some days or weeks after the causative appendicitis, existence of which may have been forgotten in the meanwhile. When secondary to ulcer of the duodenum or stomach or to infection in the biliary passages, there will be some history of indigestion that should serve as a clue to their origin. Patients with retroperitoneal infection almost invariably have a high temperature; when associated with an appendicitis, the temperature is almost always higher than that which we find with a simple uncomplicated case. At the same time there is a definite spasm of the quadratus, with deep tenderness, malaise, and general evidences of sepsis. A sudden rise of temperature, together with lumbar spasm coming on during convalescence after appendicitis, is strongly suggestive of retroperitoneal infection that has failed to subside with the removal of its source of infection.

Treatment.—In the early stages large, hot poultices will frequently give permanent relief. If not, a free lumbar incision should be made. Where pus has accumulated and tends to point along the iliac crest or in the groin, free access to the space may be obtained without traversing the peritoneal cavity, counteropenings being made in the loin if necessary.

RETROPERITONEAL GLANDS, HODGKIN'S DISEASE, ETC.

The retroperitoneal nodes may become enlarged in the late stage of Hodgkin's disease. The diagnosis should not be difficult. Over half of the cases come in early life. The general health is not at first impaired, but as the progressive enlargement of the glands downward takes place (always beginning in the cervical region, according to Reed), the patient begins to suffer from marked asthenia, cachexia, and anemia.

By the time that the abdominal glands are palpably swollen, which may be months or years after the onset of the disease, the patient is seriously ill. The spleen may be greatly enlarged and we may find pressure symptoms, such as dysphagia, edema, jaundice, etc. The disease is uniformly fatal and no form of treatment has proved of definite value. The disease is apparently a definite entity, not related to tuberculosis, according to the investigations of Reed and others; possibly it is some form of sarcomatosis, as later investigations suggest.

The lymphatics may be infected with tuberculosis as part of a general process, from local foci, or, apparently in some cases, primarily. Osseous or visceral lesions will serve as the starting-point in most cases, and the gravity or outcome does not differ essentially from similar infections in the lymphatics elsewhere. Infection of the chain lying alongside the vertebral column may produce symptoms of tuberculous osteomyelitis, and if the glands break down the pus tends to follow the same route as in the ordinary psoas abscess. In the stage of infiltration the glands may occasionally be palpated as deep, tender nodules. If the glands, instead of softening and discharging, become cheesy and calcareous, they may easily be mistaken for a renal stone or a bony deposit when photographed by the *x*-ray. In the mesentery they may become infected singly, in large groups, or universally. A few glands so infected may cause symptoms of acute intestinal obstruction with colic, fever, and local tenderness. If the glands ulcerate one or more loops of intestine may become adherent to the mesentery. Thus, we will find evidences of acute strangulation, intra-abdominal hernia, or volvulus. Where possible it is well to enucleate such nodes if a resection is not indicated. In children, however, it should be remembered that the mesenteric lymph-nodes are normally quite conspicuous throughout the abdomen. It is only when they attain considerable size that they cause symptoms. Occasionally a mass of glands will soften and discharge spontaneously into the general cavity, the lumen of an organ, or externally. Diagnosis of tuberculous retroperitoneal noditis is not always easy. When part of an extensive tuberculous lymphadenitis, similar nodes will be found in the neck, together with foci in the lungs, bones, intestines, etc. When limited to the abdomen we may find evidences of intestinal ulcers, of a chronic appendicitis or salpingitis, a tuberculous peritonitis, or of a spinal caries. Groups of enlarged glands will appear as tender, nodular tumors, usually in the oblique line of the mesentery, often quite movable when no secondary infections have fixed them to the posterior wall. In the iliac fossa they lie immovably adherent to the floor, and may be palpated as more or less discrete nodules or as indefinite irregular masses. If the retroperitoneal chains attain any great size they may cause intestinal and gastric disturbances in the same way as do other retroperitoneal tumors. It may be difficult to differentiate these nodes from malignant tumors, but there is more likely to be persistent irregularity in temperature and the young are more liable to this infection than adults, although this is by no means a definite rule.

The treatment is, first of all, hygienic and climatic. Where definite local foci, such as a tuberculous appendix, tube, or intestinal ulcer can be removed, it is best eliminated if possible. Single nodes may be dissected out without danger to the intestine. To remove large masses will necessitate intestinal resection, the justification for which depends on the individual case and the skill of the surgeon. Abscesses may be drained and the cavities treated with iodoform, but whatever is done the patient himself should be subjected to as rigid climatic treatment as one with pulmonary tuberculosis.

Sarcoma and carcinoma of the retroperitoneal nodes may be primary or secondary. They will be considered under Retroperitoneal Tumors.

RETROPERITONEAL TUMORS.

If we consider the great variety of structures in the retroperitoneal space, it is not to be wondered at that pathologic lesions and new growths of all characters should be found there. Those incident to the kidney, adrenals, pancreas, and uterus alone form a large and important group by themselves, but they will not be considered in this chapter. All that concern us here are derived from the cellular tissue, the lymphatics, and from developmental rests.

Lipomata.—Lipomata are among the relatively more common new growths. Although they are not malignant in the sense of producing metastases, they are very fatal to life, and even if removed they may recur locally. A large number take origin in the renal region, others in the mesentery or at its root, while others again may start from the lower half of the abdomen in the pelvis or in the iliac fossa. They usually come in middle life, although cases have been reported a few days after birth. Slow in growth, they cause extreme emaciation and, in many cases, death two or three years after their discovery. Occasionally, spontaneous cessation in development takes place after partial extirpation or from no discoverable cause. From small harmless nodules, single or multiple, they may grow to an enormous size, completely filling the abdominal space. In course of development they may completely surround adjacent organs, like the kidney or spleen, ureter or vas deferens, and cause pressure atrophy. On the other hand, they may push structures to one side to great distances. In some cases the cecum, appendix, and colon have been almost completely embraced in a lipoma. Pressure on the veins may cause marked dilatation extending into the anterior wall. In cases of long duration we may find ascites. Upward pressure may cause dyspnea, especially when the patient lies down. Pressure upon the biliary tracts will produce jaundice.

Lipoma may originate in the mesentery, but almost without exception the large, so-called mesenteric lipomata have started at the base of the mesentery, and, pushing forward between its leaves, have assumed the appearance of genuine mesenteric tumors. (In 1900, Heinricius could find only 1 case of genuine lipoma of the transverse mesocolon, the case being reported by Alsberg.) In a similar way, so-called

omental tumors may originate. The tumors which push into the mesentery will exhibit the intestine coursing over their surface. Those tumors which form alongside the iliac vessels in the pelvis will follow the line of least resistance and push upward to the renal region. Some of the lipomata forming in the lower abdomen will push the bladder and urachus to one side, together with the lateral peritoneum. Others forming in the iliac fossa may push under Poupart's ligament and appear as tumors on the upper thigh, causing severe pain in the knee if the nerve is stretched over the growth. On opening the abdomen a fatty tumor appears as a yellow, semifluctuating, lobulated mass under a thin translucent peritoneum; when lying within the mesenteric leaves numerous and large vessels will be seen passing over its surface. If the tumor thrusts itself well into the mesentery it may peel off a portion of the serous coat of the intestine.

Their **etiology** is obscure. They do not necessarily come in the obese. On the contrary, as the lipoma increases we find extreme marasmus. Women are more inclined to this form of growth than men. In large tumors, though it is less true of the pure lipomata than of the malignant growths, secondary vascularization may take place at any point or points on its surface, and a large vessel extending into its substance will not necessarily indicate its local origin.

As types of growth we may find pure lipoma, fibrolipoma (in which the fibrous elements vary in amount), and lipoma with myxomatous and sarcomatous degeneration. Occasionally portions may show calcification or even osteoid deposits. Any of these types may break down and form large abscesses, and Vander Veer has reported a fungous protrusion of a cystic myxosarcomatous lipoma. Of 35 cases collected by Begouin, over half were pure lipomata, while the remainder were combined with some other form of connective tissue.

The **diagnosis** of retroperitoneal lipoma is not easily made. Patients complain of a slowly growing tumor, steady emaciation, dyspnea, sometimes of edema of the lower extremities, intestinal or gastric indigestion from pressure by the growth, occasionally of dysphagia. Sometimes we find vomiting or diarrhea or vesical disturbances. Examination will show a tumor generally on one side of the median line, semifluctuating and lobular, or if fibrous, it will be hard and nodular. Mobility may be present, especially from side to side. Percussion will show in the typic large growth a central area of flatness surrounded by a circle of tympany due to the arrangement of the colon. The small intestines may be pushed to any portion of the periphery, and in Trendelenburg's position the tympany due to their presence in the hypogastrium will assist in differentiating these tumors from pelvic cysts, with which they are liable to be confounded. Smaller growths, with a flattened gut lying anteriorly, will exhibit varying degrees of tympany.

The transverse colon is apt to lie in front of the tumor, but the stomach may be pushed far to the side, together with the small intestines. In other words, the relation of the gastro-intestinal tract depends

upon the location and degree of the forward thrust of the lipoma, and no definite relation can be considered as constant. Occasionally patients will complain of a periodical intestinal occlusion. As indicated before, large growths will cause dyspnea.

Treatment.—The treatment consists in removal by enucleation. In the simpler forms starting in the lumbar region, and where secondary changes from pressure or degeneration have not arisen, this is easily accomplished by following the lines of normal cleavage, keeping, as Reynolds and Wadsworth have demonstrated by dissections, posterior to the prerenal fascia which separates the tumor from the important vessels. When, however, there is fusion from pressure or other cause, enucleation may be very difficult or impossible. The blood supply to portions of the intestine may be cut off in the course of dissection or the adherent intestine itself may be damaged, necessitating resection. A kidney compressed and atrophied by pressure may have to be removed with the tumor. The vena cava may be torn and require ligation or suture. The spleen has been fatally torn in removal of a lipoma. The lateral growths can be attacked from the flank or lumbar route, preferably the former. Others must be approached by the nearest route. In the rarer pedunculated types there will be a rich vascular supply at the root. At times adhesions to the peritoneum will be rich in vessels and require great care in dissection. As there may be multiple tumors, it is necessary to examine other parts of the posterior wall for additional growths. After removal of the large tumors it is safer temporarily to drain, because of the great amount of serum often mixed with blood. Exploratory puncture is useless and dangerous. Exploratory incision is to be recommended instead.

The **prognosis** is not good. Patients with the large tumors may succumb to shock, post-operative infection, or intestinal gangrene. Some have died from diarrhea, apparently dependent on interference with the intestinal nerve supply. The necessary nephrectomy, intestinal resection, or other organic interference may prove fatal when added to the shock of excision of the tumor. Several surgeons have seen a local recurrence after enucleation, but, on the other hand, a number of cases have ceased growing after partial enucleation. Occasionally a tumor will break down and discharge pus, followed by tedious recovery or by death from exhaustion. The fibrous types may become sarcomatous and prove fatal primarily or secondarily by metastasis or recurrence. About half of the cases operated upon have recovered, many of the bad results, however, coming in cases with enormous tumors allowed to grow until surgical interference was invoked as a last resort.

Lipomata must be differentiated from the various pelvic tumors, retroperitoneal cysts and sarcomata, tumors of the various deep organs, etc.

Myofibroma.—These tumors are most commonly seen originating from the uterus and pushing upward under the peritoneum. They will be considered in detail in the chapter on the Surgery of the Female Generative Organs. Occasionally they are found originating higher up

in the retroperitoneal space, and assuming the characteristics of a fibrolipoma, except that they do not attain the great size of the latter. If they become myxomatous, however, they may grow to a large size. Doran successfully removed one weighing 30 pounds. This form of tumor apparently tends to form secondary blood supplies and is more vascular than the purer forms of lipoma. Its favorite location appears to be at the root of the mesentery of the small intestine, though it may push between the leaves of the mesocolon or elsewhere. Myofibromata may be multiple as well as single.

Similar in gross appearance is the very rare *ganglioma* (*Neuroma gangliocellulare*). Busse removed a large growth of this type from a child who had paralysis of the lower extremities, the sphincters, etc. The growth involved the first four and upper half of the fifth lumbar segments, extending from the lower ribs to the greater pelvis, most of which it occupied. Removal of most of the growth was followed by recovery, but without return of the motor functions.

Simple fibroma of the psoas iliacus has been occasionally reported, but, as malignant tumors are more apt to be found in this region, its general consideration will be deferred until the section on Sarcomata.

Gumma of the mesentery causing intestinal obstruction has been removed successfully. A rare *amyloid tumor* of the lymph-nodes has been reported by Tschistowitsch in an adult male. The patient suffered early from severe pain, later developing the signs and symptoms of a polyneuritis with emaciation, ascites, and anasarca. At autopsy a large tumor, occupying the center of the abdomen and pushing apart the mesenteric leaves, was found. Amyloid degeneration and hypertrophy of the retroperitoneal and mesenteric lymph-nodes existed, the tumor being intimately adherent to the spine. Section showed enlarged and changed lymph-nodes, thin walled cysts with transparent fluid, and, in places, cheesy masses. Although originating in some form of intoxication, the cause of the hypertrophy and degeneration was obscure.

Cysts.—Retroperitoneal cysts of most varied types may be found. The origin of some, such as the echinococcus, the pancreatic, the blood, and the teratoid cysts, is fairly clear. But there are other cysts that are so obscure in their origin that no explanation is forthcoming, either at operation or on pathologic section. Mesenteric cysts may originate in the posterior cellular space. On the other hand, according to Narath and others, a mesenteric cyst may push backward into the posterior space so that a differentiation is not always possible.

Echinococcus cysts are occasionally found here, but much more rarely than within the peritoneal cavity. They may form centrally in the pelvis or in the region of the kidneys. They may be primary or secondary. Extirpation *in toto* is best, if possible; otherwise, incision and drainage, avoiding contamination of the peritoneal cavity with the cyst contents. In the flank the cyst may be extirpated extraperitoneally, and, as in one of my own cases, the kidney may be so atrophied by pressure that nephrectomy will be required.

Cystic degeneration of the lymph-nodes is another rare form of cyst found in this region, usually in the neighborhood of the kidney. Potal thinks that such formation may take place in cases of tuberculous noditis.

Cysts originating in the lymphatic vessels is another form which varies in its manifestations. These chylous or lymph cysts may form large tumors in any portion of the abdomen, even pushing downward into the upper thigh. Their origin is not clearly established. The thoracic duct itself may become obstructed, they may come as extravasations of lymph from lymph-nodes, or from other portions of the lymph vessels, or from lymphangiomata. It is possible that they are the result of chronic inflammatory hypertrophy of the endothelium of the lymph-nodes (Tilger). The fluid is turbid or milky, containing finely emulsified fat, a high percentage of albumin, endothelial elements, and sometimes cholesterine and other constituents. The cysts are generally sessile or spread out, but Sarwey removed a large cyst from a young girl that had pushed forward between the stomach and colon, and that was united to the pancreas by a small pedicle containing milky fluid, but it could not be demonstrated as originating from that organ. Tilger found a small cyst of this type in the layers of the lesser omentum, containing a yellow fluid with shining flakes, fat drops, and granules. Opposite the cyst, in the lesser curvature of the stomach, was the scar of an ulcer. The cavity was apparently formed by the dilatation of the lymph channels. Reimers also observed a lymphangioma of the stomach that he attributed to the closure of the lymph channels by the scar contraction of a large ulcer. These cysts can usually be easily enucleated; if this is not possible, they may be drained with a goodly chance of success.

So-called *blood cysts* may start from injury, from hemorrhage in broken-down tumors of various types, from spontaneous hemorrhage in hemophilia, from circulatory disturbances, and from hemorrhagic inflammation. That hemorrhage is the origin of many of the simple retroperitoneal cysts is far from proved, and, in some of the latter, evidences of bleeding do not necessarily determine the origin. True blood cysts may form rapidly and produce active symptoms. Their location is not limited to any one part of the abdomen. Pawlik has successfully removed an adrenal because of a traumatic cyst of that organ. Blood cysts involving the iliopsoas are not very rare. The symptoms may simulate those of tuberculous joint disease. In the region of the mesentery they may occasionally cause obstruction.

Retroperitoneal serous cysts may originate in the Wolffian or Müllerian ducts, or from hematomata, but in a good proportion of cases their origin cannot be definitely established. It is probable that some of the indefinite types may be pancreatic in origin, all trace of the original organ and its secretion being obliterated by time and pressure, but until more and better data are at hand we must be content to accept not a few of these cysts as obscure in origin. Symptoms and location do not establish their origin. Chemical and histologic exam-

ination may elucidate some of them. They may not be recognized until after death or until pressure symptoms call the patient's attention to their presence. The walls are thin, strong, and generally, but not always, separated from the surrounding tissues by a loose connective layer. Their contents consist of a thin fluid of low specific gravity, containing little albumin. The kidney may be absent or rudimentary on the side on which these cysts develop from the primitive ducts.

The simple cysts may attain enormous size, as witness, the tumor found at autopsy in an old man by Przewoski. The patient had suffered from abdominal pain and nausea, later from cough and dyspnea, for three years. The fluid was of low specific gravity and the cyst could have been easily removed. Like most of these tumors it was unilocular. Koeberle states that the patients are frequently well nourished and healthy appearing. The cysts may be slow in growth, and though attaining enormous dimensions they do not necessarily become adherent to the organs. On the other hand, small cysts may prove very adherent. They are almost always found in adult males. Enucleation is usually not difficult; if it is, incision and drainage will prove sufficient for a cure. In my own experience, those which lie to one side of the spine can be removed satisfactorily, while those which present themselves in the median line, between the stomach and the colon, cannot be removed, but if drained thoroughly they show no tendency to recur, at least within a space of two or three years.

The *teratoid tumors* of the retroperitoneal space vary in character, from the simplest (dermoid) types to the most complex, including those which are supposed by some writers to represent bigerminal implantations. The simple forms are found, preferably, in the large omentum and in the mesentery of the small intestine, those originating in the Wolffian duct lying behind the peritoneum in the loin. They may be solid or polycystic, and are generally easily enucleated. The complex forms will contain hair, bones, etc. Both sexes are subject to these growths. Although most of them develop from the Wolffian tract, yet, occasionally, a tumor may be found at such a distance from this organ that it must be explained by the development of an epidermic germ or by some disturbance in the closure of the abdominal fissure. In the anterior wall we have seen that such dermoids may come from imperfect closure of the vitelline duct. Cases are reported at various periods of life, but more in early than in later life. At times the tumors reach great size, weighing twenty pounds or more. Associated with them we will find normal ovaries or testes. Lexer has studied them most thoroughly, and for a full account of the theories as to their origin and formation, his monograph should be consulted.

Diagnosis.—The diagnosis of these various cysts is not easy. Symptoms of dyspepsia and indigestion, without corresponding chemical changes, the presence of a tumor, tense or fluctuating, which displaces the stomach and intestines, evidences of pressure upon the circulation, as shown in dilated veins, ascites, anasarca, etc., are found. The relative position of the colon and stomach, as brought out by insufflation,

may throw some light on the diagnosis. Abdominal exploration is the only definite means for determining the position and probable nature of these tumors, and an early exploration is more than justified. Aspiration should not be allowed.

Excluding the teratomata that become malignant early in their history and the cysts that develop from degeneration of malignant tumors, the prognosis is good. Enucleation, when possible, or incision and drainage with destruction of the secreting lining, should this be present, will cure most cases.

Any of these cysts may cause a partial or complete obstruction of the intestines, pressure-atrophy of different organs, neuralgic pains, and joint-spasm from nerve-pressure. They must be distinguished from intraperitoneal tumors and from the cysts or tumors of the kidney, pancreas, and genital organs. Tumors of the kidney may show evidences of their presence in the urine. Tumors of the pancreas may be accompanied by fatty stools, marked and progressive digestive disturbances, and occasional glycosuria, but none of the latter symptoms are characteristic, especially of the simpler pancreatic cysts.

Retroperitoneal sarcoma may be primary or secondary. In the latter case the primary focus can usually be found in one of the ovaries or testes, in the lower extremities, or in some other distant point. The origin of the primary tumors is obscure in some cases. They may start from the fascia, including the periosteum, the glands, the vessel sheaths, or from a misplaced organ or genito-urinary rest. Koenig regards the slow-growing types as fascial in origin, whereas the rapid sarcomata start in the glands. The theory of their origin in the accessory organs of Zuckerkandl lacks confirmation.

Sarcoma is found in the first, fourth, and ninth decades, according to Steele, who has collected 96 cases. He found 1 case reported in a baby under one year, and another in a patient eighty years old. Generally hard and lobulated, it tends to break down or to become hemorrhagic. If degeneration (mucoid or purulent) proceeds rapidly, the tumor becomes cystic in character. Perforation into one of the viscera, the peritoneal cavity, or through the posterior wall, may take place. Death comes about a year after discovery of its presence. The rate of growth is faster than that of the lipomata, but primary sarcomata do not attain so great a size as the former. If, however, a lipoma becomes malignant, its growth-rate rapidly increases. Unlike sarcoma elsewhere, it is difficult to ascribe any causative relation to trauma. All types of sarcoma are met with. In situation, they are lateral rather than central; they come in the upper, the pelvic, and the iliac regions of the abdomen, and may be single or multiple. Metastases may be found in practically any organ of the body, those in the liver and lungs being most common. From the nature and form of growth the tumors are generally immovable, but occasionally one will be found that is movable laterally or with respiration. In the presence of solid tumors in this space sarcoma, either primary or by secondary degeneration, must be suspected. Rogowski found sarcomatous tissue

in every one of twenty solid tumors collected by himself. These tumors, at least early in their growth, are encapsulated.

The **diagnosis** of retroperitoneal sarcomata is not easy. Their early recognition is important from the fact that not infrequently they remain isolated, enucleable, and without metastases for some time. Obscure digestive symptoms associated with rapid loss of weight and strength, independent of the chemical changes that come with gastric lesions, deep-seated tumors that are slightly tender, and abdominal pain, are the best data in arriving at a diagnosis. The digestive symptoms may vary from indefinite distress or uneasiness after eating, to intense colic, similar to that seen in gall-stones. The onset of symptoms is insidious, but they persist and do not entirely disappear. Steele classes diarrhea as an important symptom. My own cases have almost invariably shown constipation. This, together with the gastric distress, has deceived me into considering the cases as ulcer or cancer of the stomach. Although these patients do not show the regular rise of temperature that we find in tuberculosis of the abdominal lymph-nodes, yet the victims of sarcoma do show irregular elevations, the presence of which is not to be interpreted as ruling out malignant disease. As in other retroperitoneal growths, we may find intestinal obstruction of different degrees. In the pelvic and iliac growths neuralgic pains and edema of one or both lower extremities, interference with the bladder functions, as in prostatic growths, ascites, and rectal disturbances may first call the patient's attention to his trouble. At times there will be edema of the scrotum, dilatation of the parietal veins, and in the higher tumors, jaundice. Osler has reported a case of polyuria possibly due to one of these tumors. The position of the viscera, in relation to retroperitoneal tumors in general, holds good in relation to sarcoma, but in the primary growths a tumor large enough to give characteristic signs will be beyond surgical help. A large central tumor will push the small intestines to one side, usually to the right, and be framed by a zone of tympany from the encircling colon. The latter may, however, cross in front of the growth and be apparent only on insufflation or when distended with gas. If the growth is large enough to approximate the anterior wall the percussion will be flat at this portion.

There is no way to tell when a benign tumor, like a fibrolipoma, degenerates into a malignant tumor. The possibility, or rather, the probability of such a degeneration is argument enough for early removal. The primary sarcomata, early in their course, are to a considerable extent local and easily removed, but, unfortunately, it is rare that patients seek surgical aid early.

The **treatment** consists in removal by enucleation or dissection, sometimes with resection of intestine, excision of a kidney or spleen, intestinal anastomosis, gastro-enterostomy, or jejunostomy, according to the symptoms. Marconi resected a portion of the vena cava in the extirpation of a voluminous prevertebral lymphosarcoma without bad results. Edema of the lower extremity appeared the following day, but at the end of a month it had subsided.

Attack is best made from in front, even when the tumor is situated in the perirenal region. Small iliac tumors may be reached extraperitoneally or by the combined extra- and intraperitoneal route. In hopeless cases the serum treatment is worthy of trial.

The **differential diagnosis** between primary retroperitoneal sarcoma and the various tumors of the retroperitoneal organs (kidney, pancreas), malignant disease of the stomach, intestines, gall-bladder, prostate, etc., is not easy or often possible at any stage of growth, and, for that matter, it is not important from the point of view of treatment. All of these confusing conditions are surgical from the very beginning. In suspected syphilis treatment should be carried out for as limited a period as is consistent with obtaining definite results from iodid or mercury.

Tumors of the ilio-psoas muscle, though included in the foregoing, are important enough to merit short consideration by themselves. All types of growth may be found here: benign or malignant, cystic or solid, but, fortunately, they are comparatively rare. As elsewhere, the growths may be primary or secondary. The symptoms are pain in the iliac fossa radiating into the lower extremity, neuralgic pains referred to the course of the crural nerves, edema, phlebitis, impaired joint motions, and sometimes pelvic and urinary symptoms. Tumors which lie over the muscle will be made prominent by muscular contraction, while those which lie beneath will be obscured. They are apt to be diagnosticated as inoperable pelvic tumors, whereas, some of them are easily enucleated extraperitoneally.

PERITONITIS (ACUTE AND CHRONIC).

Inflammation of the peritoneum may be aseptic, or, most commonly, septic. The *aseptic type* is caused by mechanical or chemical agencies, that is, the presence of foreign bodies such as sponges, ligatures, etc., will cause a varying degree of peritonitis, which beyond producing adhesions and their secondary results may not do harm. Here, too, should be included the aseptic peritonitis that comes from hemorrhages incident to trauma, ectopic gestation, and the outpour of the various aseptic fluids from a ruptured gall-bladder, urinary bladder, kidney, cysts of various sorts, etc. Rough sponging at operation and irrigation with strong chemicals will also act as a cause. The transitory peritonitis that is secondary to volvulus, intussusception, and twisted pedicle may be aseptic, due to the transudation of blood and serum, but it is much more likely that there is a minimum amount of bacterial infection that is rapidly and easily disposed of in the cases that go on to spontaneous recovery. That the aseptic type is most liable to become septic by the invasion of bacteria is a well-known fact, and it should always be in the mind of the surgeon in dealing with this form of peritonitis. The appearance of the peritoneum in this form of inflammation is the same as that in the milder septic form—a rough, reddened peritoneum, sometimes flakes of fibrin, clear or slightly cloudy serum, and,

eventually, adhesions of various peritoneal surfaces. In this connection it is well to call attention to rare instances of chronic adhesive peritonitis in which no bacterial (tuberculous, pyogenic) or malignant origin can be demonstrated. That there is some infecting microörganism seems certain, but its demonstration is at times impossible. Such patients appear to have individual idiosyncrasies for the formation of adhesions throughout the peritoneal cavity. If operated upon and the adhesions obliterated by plastic methods, new and healthy looking surfaces at once form unions which increase rather than diminish, as is the rule in most cases of peritoneal adhesions. The pathology of these cases is still obscure.

Septic peritonitis, one of the most important diseases that surgeons have to deal with, is due to the infection of the peritoneum by any one of the various pathogenic bacteria. The various types may be roughly classed as serous, fibrinous, purulent, and when there is necrosis of the peritoneum and its underlying layers, gangrenous. More than one type may be present at the same time, and the distinction between different types is rarely a sharp one. A peritonitis may be local, diffuse, or general. The cases of genuine general peritonitis are comparatively few, although writers often carelessly describe the diffuse forms as general. So far as the patient and surgeon are concerned, a diffuse septic peritonitis is about as serious as a general peritonitis. I believe it to be better to drop the latter term, except in rare instances.

The immediate dangers arising from peritonitis are sepsis, intestinal paresis, shock, and pain, any one of which may cause death. The remote dangers are manifold—acute and chronic obstruction of the stomach, intestines, or bile passages from adhesions, bands, twists, invaginations, etc., interference with the functions of various abdominal organs, persistence of septic foci, long persisting pain and discomfort, secondary mental and nervous phenomena, etc. Any one of the types of peritonitis may prove rapidly fatal, and any one may be followed by recovery. In general, the danger is dependent upon the virulence of the infection, the area infected, and, to some extent, the region infected. Under the term virulence we should include not only the species and the activity of the infecting organism or organisms, but the dose of the infection, whether gradual or overwhelming, and the individual power to dispose of infecting agents, which varies with age, habits, general condition, etc. Small areas of infection, when limited and prevented from infecting new areas, are cared for in a majority of patients in course of time. This is most manifest in the so-called cases of preperforative peritonitis. A limited necrosis, such as may take place in typhoid fever, ulcer of the duodenum, or perforating appendicitis, allows penetration of bacteria or toxins which cause a local peritonitis with adhesion and thickening. This forms a protective seal, provided that the necrotic process does not increase or there is no sudden augmentation of pressure toward the general cavity. Otherwise, a serious or fatal outpour of foreign material may take place. The proper understanding and recognition of this preperforative protecting inflammation is of the

utmost importance for the physician in charge of patients suffering from typhoid, appendicitis, etc. Spreading infections uncontrolled by delimiting adhesions are progressively more and more serious, as one area of the cavity is involved after another. So in sudden outpourings of septic material, flooding the cavity before the peritoneum has had an opportunity to erect its defensive adhesions, we are sure to find frightful or even fatal shock and infection.

As to the locality infected, other things being equal, a septic peritonitis in the lower (pelvic) portion of the belly is less to be feared than the same infection in the upper (diaphragmatic) portion, because of the much more rapid and voluminous absorption through the diaphragm and omental lymph spaces. Lennander has shown that an infection of the center of the abdomen below the colon and above the pelvis may spread over a large area among the small intestines without producing symptoms. This holds good of any peritonitis above the pelvis, which touches the parietal peritoneum only in part, or not at all.

However we may look at it, a peritonitis is, or may be, a menace to a patient's well-being or his life. The mere destruction of the peritoneum itself is of less moment than the absorption of toxins, shock, or after-complications. In fact Friedlander has shown that the entire peritoneal membrane may be obliterated by chronic inflammation without destroying life. A free, purulent peritonitis, even of limited area, is less amenable to surgical therapy than a peritoneal abscess, that is, a case that protects itself by adhesions lessens its liability to septic absorption. A free peritonitis spreads its infection both by the migrating lymphangitis in the subserosa and by an extension of the exudate in the free cavity. The toxins poured into the general circulation poison the vasomoter and the respiratory centers, the first being attended by an engorgement of the peritoneal veins. This very hyperemia may be an important agent in resisting infection in the early stages, and according to Lennander it may be compared to Bier's treatment by hyperemic engorgement. As soon, however, as this hyperemia interferes with the normal functions it loses its virtue and becomes an added danger.

Absorption activity has been demonstrated to be increased in the early stages of peritonitis. It is hindered in the presence of the serous or purulent exudate, when the toxins are diluted. Thrombosis and pressure of the blood and lymph capillaries also check absorption. In certain stages the absorption may be so impeded that there is, practically, absence of resulting symptoms, such as fever, albumin, and hyperleukocytosis, although both preceding and following this stage we will find all these indications of sepsis present. Lennander has shown that in advanced acute peritonitis the intestinal paralysis is from toxic or bacterial poisoning of the intestinal walls, with manifest changes in the ganglion cells of Auerbach's plexus. As distention increases, thrombosis and gangrene develop, and the gut becomes more easily penetrable to bacteria, and thus a continuous reinfection is produced. Furthermore, the general systemic infection is added to by absorp-

tion of toxins from within the gut; toxins that are most virulent in themselves.

Buxton and Torrey have shown in animals that typhoid bacilli injected into the peritoneal cavity are rapidly destroyed at first. Later, the process is slower, but there is no evidence that they are taken care of better in the organs (liver and spleen) than in the peritoneal cavity. They have shown that, probably, in the organs as well as in the cavity itself there is usually a rapid, extracellular bacteriolysis at first, and after this has expended its force the phagocytes continue the process, but more slowly. The initial destruction may be explosive in character or it may extend over the space of an hour or more. After an injection of bacilli or inert particles there is an immediate rush to the lymphatics of the diaphragm, thence to the anterior mediastinal lymph-nodes and thoracic duct. Up to the point of reaching the organs the particles are at first free, later being taken up by the phagocytes. Phagocytosis by macrophages is most active in the mediastinal lymph-nodes. As fibrin is formed and deposited on the omentum the particles and phagocytic cells become entangled, and the macrophages, which are more active than the polynuclear leukocytes, rapidly englobe the particles. Bacilli become fixed in great numbers on the surface of the omentum, free or in the fibrin, or contained in the macrophages. Thus, they may be rapidly destroyed within or without the cells, or even may remain intact for some time. The authors were unable to determine definitely whether the particles pass by way of the so-called stomata or between the endothelial lining cells. According to Warbasse the existence of stomata has not been established, but, be that as it may, the absorption of septic products, whether by osmosis or by cellular action, or both, is remarkably active in the region of the diaphragm and in the omentum. This property is of the utmost importance in treating peritoneal sepsis, medically or surgically. It is both the safeguard of the patient and the surgeon's ally up to a certain limit, a limit which must vary considerably in different individuals. On the other hand, it may be a qualification most dangerous to the patient, by allowing absorption of overwhelming doses of toxins that cannot be resisted by the system in general.

The sources of peritoneal infection come almost without exception from the outside, that is, through the walls of the cavity or from some one of the intra- or extra-abdominal viscera. It is well established that bacteria or other products may migrate through the wall of the intestine that has been very slightly damaged. It has not been proved that they pass through the healthy wall. Certain rare infections, such as are found in acute rheumatism of the joints and in nephritis, are apparently hematogenous, but probably some better explanation will eventually be found.

Inflammation of the appendix and bile passages, ulcerations, and perforations of the gastro-intestinal tract, the passage of infections through the Fallopian tubes, thrombosis of any portion of the intestinal

tract secondary to mechanical disturbances, the rupture of abscesses of any of the organs in relation to the peritoneum, and wounds of the parietes or viscera are among the usual sources of peritonitis. Broadly speaking, any lesion of an organ lying contiguous to the peritoneum may serve as a source of infection, provided there is sufficient necrosis of the intervening tissues to allow the transmigration of bacteria or their products. Although the peritoneal infection is secondary to lesions of some organ or structure it may become primary in importance. On the other hand, we may find very mild, peritonitic evidences in serious organic lesions. In either case it is of the greatest importance to recognize the lesion of origin, to deal with that as well as with the peritonitis, or, as Lennander has so properly stated, an early and definite diagnosis must be made in order to eliminate the source of infection, which, in the majority of cases, can be done safely and easily, provided that recognition comes before the peritonitis attains primary importance. In other words the most important agent against acute peritonitis is prophylaxis or preventive surgery. A closer study and diagnosis of all diseased conditions which can cause peritonitis, and a more careful observation of the preperforative stage of the different abdominal lesions will help us to attain this end.

Warbasse emphasizes the important rôle played by the subperitoneal cellular tissue, with its rich supply of lymphatic and blood-vessels. This is seen especially in certain types where there is great thickening, edema, or purulent infiltration of the gut-wall, omentum, or mesentery, but in which slight changes in the peritoneum itself are visible. The bacillus coli is the most common bacterium in infectious peritonitis. Next to this come the streptococcus, the staphylococcus, the gonococcus, the pneumococcus, the B. pyocyaneus, etc.

In the early stages of infection we find injection of the peritoneal vessels, a roughened appearance of the peritoneal surface with loss of its normal sheen, and a clear serous exudate which rapidly becomes cloudy and purulent from the migration of leukocytes and bacteria. We may also find hemorrhagic effusion, especially in peritonitis due to twists, strangulation, thrombosis, etc., and rarely, free gas, not due to perforation of the gastro-intestinal tract, will be manifest on opening the abdominal cavity. Flakes of grayish-white fibrin are found, often increasing to such an extent that they form large deposits or masses agglutinating the coils to one another and to the surrounding tissues. The gross appearance of the exudate is not necessarily an index of its toxic properties. A cloudy serum, so frequently found throughout the cavity, associated with a gangrenous focus, is not necessarily more than very slightly septic, while, on the contrary, the thin, acrid serum that accompanies the fulminating streptococcic peritonitis is most virulent. It is not rare to find the abdomen almost universally bathed in a thick, creamy pus that is comparatively harmless. Examination of smears or by cultures is of assistance in most cases, and should be made as a routine.

We may find several grades of exudate in the same abdomen, cloudy

serum, coils adherent by fibrin, sometimes forming the barriers to encapsulated collections of pus or gangrenous débris, and, elsewhere, old bands or tough adhesions, the relics of former peritonitic outbursts. The normal tendency of the peritoneal cavity to absorb its free fluids, to localize its infected exudates, and, finally, to absorb its chronic adhesions, is one of the most surprising characteristics that surgeons encounter. Even within a few months we may see nearly a complete disappearance of adhesions after most severe types of diffuse fibrino-purulent peritonitis. But, as we shall see later, small patches of adhesions may fail to disappear, and we must deal with the results of bands, angulating adhesions, and broad tractions that drag organs into abnormal positions.

Symptoms.—The cardinal symptoms of a peritonitis are abdominal pain, spasm and tenderness, nausea or vomiting, and changes in pulse and temperature. However variable these may be, relatively, they are practically always present in a peritonitis at some stage. Nausea, as a symptom, varies perhaps more than any of the others, depending a good deal upon the individual equation. Not infrequently, patients have anorexia to such a degree that by self-starvation they avoid the nausea that they otherwise would have if they excited peristalsis. Pain may be so slight that it is regarded by the patient as of no significance; as the opposite extreme we sometimes find it so severe in children as to cause a fatal colapse. It may be described as sharp, dull, persistent, spasmodic, nauseating, dragging, etc. Spasm is practically always present and it almost always persists to some extent under anesthesia in the acute infections. Exceptionally, in some of the mild diffuse, purulent types, it is wanting. It is manifest on superficial palpation in most cases, especially in the acute, spreading infections. It is elicited only by deep palpation in encysted infections, where the surrounding peritoneum has escaped irritation. It is ascertainable by the surgical tactile sense, but is easily overlooked by the inexperienced. Its absence under anesthesia, where apparently present beforehand in the conscious patient, is a strong argument against an inflammatory peritonitis. To this rule I have rarely found an exception.

Tenderness is usually present with spasm, but not necessarily. It may be intense in the fulminating types. The tenderness and spasm are, with few exceptions, located over the area of most marked infection. This is not always true of subjective pain, which is frequently referred to the umbilicus when the focus is distant. As a rule, however, sooner or later the pain is referred to the area of greatest tenderness. Lennander explains pressure-tenderness by the irritation starting from the inflamed organs upon the spinal nerves of sensation, which ramify in the parietes. This is probably true as regards infections not invading the parietal peritoneum, but clinical evidence and the evidence of Lennander's experiments on peritoneal sensibility show that the parietal serosa is very sensitive, especially when inflamed, and we are fully persuaded that as soon as the infection reaches the anterior wall the pain is due to direct irritation of this region and not to any nerve

transmission. The temperature is almost always elevated, but by no means commensurate with the severity of the infection, and a slight rise may easily be misinterpreted as a safe index in diagnosis and prognosis. A high temperature usually indicates a marked lymphatic infection, co-existing with that of the peritoneum. A temperature below normal is generally seen in the early stages of the severest types. The pulse, however, is a much more reliable guide. Rarely does it fail to increase in rate and diminish in volume, and as a prognostic sign it is one of the most reliable. A pulse-rate persisting above 120 in an adult is invariably a grave sign, regardless of the temperature, the presence of tenderness, etc. Owing to the soreness and tenderness of the parietal peritoneum, patients instinctively make as little use of the abdominal muscles in breathing as possible. Hence, the rate of respiration is increased and inspiration is shallow. From lack of oxygenation patients soon become cyanotic. The cyanosis, augmented by the toxemia and weakened heart action, increases, and, accompanied by cold sweating, completes a picture that is very characteristic.

The face becomes pinched and drawn, the lips thin and blue, showing the dry, coated teeth. The tongue becomes dry, coated, and tremulous, and the eyes sunken, anxious in expression, and later, dull. As the intra-abdominal infection grows worse the extremities become cold and clammy, the skin, in general, becomes dusky, because of its sluggish capillary circulation, exhibiting purpuric areas shortly before death.

A chill due to sudden infection from a gangrenous focus may precede the peritonitic symptoms, but after a peritonitis is well established, we are not likely to find a repetition of the chill.

The urine rapidly becomes scanty in amount, high colored, and concentrated, and usually contains albumin and casts as the result of toxic nephritis. The vomiting, consisting at first of the contents of the stomach, soon becomes bilious and fecal in character. It is at times explosive, but in the later stages it is merely a passive regurgitation.

Patients with peritonitis always feel and look sick, and as the infection increases they become restless and anxious. The mind is alert and active up to the late stages, when delirium is followed by stupor and coma. The dorsal position, with the knees flexed, is very characteristic and is usualy noted in all but the mild, localized infections. This position relieves tension, not only of the anterior abdominal muscles, but of the iliopsoas. The latter region is easily irritated and inflamed in infections starting about the cecum, pelvis, and sigmoid.

Distention or meteorism is one of the earliest signs. It is the result of the attempt of the intestines to remain quiet in order to minimize the pain that comes from peristalsis. With the cessation of normal downward peristalsis, and with the inevitable diminution of intestinal absorption, decomposition and fermentation rapidly take place, and the coils become locally or universally distended with gas. In order to relieve itself a reversed peristalsis may take place in the upper intestine, forcing the contents backward into the stomach, which by vomiting and eructation rids itself of some of the contents. The relief to gas-

pressure in this manner is slight, however; the bowel cannot force the gas downward along the large intestine, which normally is more sluggish than the small gut, so that the pressure becomes more and more intense; angulations and constrictions from adhesions form, the diaphragmatic movements are interfered with, the respirations become more superficial and aeration of the blood is reduced. The heart's action is more and more embarrassed by the pressure from below, until finally, death comes as the result of a culmination of the various interferences with the vital functions. The formation of free fluid may take place to a moderate extent. It almost never is sufficient in amount to cause trouble. Its presence cannot be easily or accurately determined by percussion, and, for that matter, a knowledge of its presence is of little moment in diagnosis.

In local collections of purulent exudate the symptoms approach those of an abscess elsewhere. A temperature that is usually moderately elevated, a quick pulse, local tenderness and pain, varying degrees of disturbance with the intestinal functions, rarely chills, unless there is a formation of new collections of pus. Urinary retention is not uncommon. The causation seems analogous to that of gas retention in the bowels. Frequent and painful urination may also be found in infections involving the viscera adjacent to the bladder.

Diagnosis.—A diagnosis can generally be made by a consideration of the typical signs and symptoms outlined above. There are, however, a variety of pathologic conditions that mimic the symptoms of a peritonitis and which mislead the best of surgeons into operation. Among these we should include the early stages of the acute eruptive diseases in children before the cutaneous manifestations are evident; acute nephritis, lead poisoning, pancreatitis, acute toxic gastritis, infection of the cellular tissues of the parietes, especially in the space of Retzius, renal and biliary calculi, and even hysteria; hemorrhages and abdominal pains of obscure origin in typhoid, orchitis in gonorrhea and mumps, and most important of all, the abdominal crises in acute pulmonary diseases, notably pneumonia. This last condition is most frequently mistaken for peritonitis or appendicitis, especially in children, and there is no surgeon of experience who has not seen a number of cases. Fortunate is he if he has escaped the embarrassment of a needless laparotomy. These patients fail to exhibit a genuine spasm, and the temperature and respiration are elevated out of proportion to the abdominal signs. A careful auscultation will often show suspicious, if not typical, pneumonic signs in the chest.

An acute intestinal obstruction from mechanical causes (twists, bands, internal hernia, coproliths, etc.), will strongly suggest a peritonitis because of the pain, colic, vomiting, and meteorism; but until a peritonitis develops secondarily there is an absence of spasm, rise of temperature, leukocytosis, and the general facies of an inflammatory disturbance. An enema will usually bring flatus and feces early in peritonitis, but not in obstruction. In late peritonitis, with paresis, when enemata are ineffectual, the typical signs and symptoms are too well marked to

warrant the error in diagnosis that is so often made. Mechanical obstruction is relatively rare; inflammatory obstruction is very common. The latter is preceded by hours and days of illness that lead up to the obstructive stage. The former comes suddenly, and rarely with premonitory symptoms.

Prognosis.—The prognosis in peritonitis depends so much upon the extent, type, virulence, and treatment of the infection, on the individual, and on the various possible sequelæ, that no general estimate is possible. Any peritonitis may be directly or indirectly fatal. Much of it is serious, but with modern surgery the prognosis, broadly speaking, is far better than heretofore. The diffuse, spreading, streptococcic forms are almost always fatal from a general septic infection. Some, apparently the most hopeless, recover both by medical and surgical treatment, and no case should be condemned as hopeless so long as there is life. The localized types offer a better prognosis, best under surgical treatment, though some recover spontaneously, as we all know. The best prognosis, a prognosis that is almost perfect, attends the cases that seek surgery in the earliest hours, before absorption, before diffusion, and before meddling by internal medication. Barring the rare accidental calamities that come with surgery of any part of the body, it is not to be gainsaid that if it were possible to treat surgically every case of peritonitis within twelve hours, at most, after its onset, the mortality from peritonitis would fall to a small fraction of 1 per cent. In other words, skill in diagnosis, enabling us to recognize the causes and first symptoms of peritonitis, skill in operative technic, and skill in after-treatment will rob one of the dreaded lesions of the body of practically all of its horrors. Every surgeon of experience will frankly assert that a large share of his deaths and bad results come not from surgery, but from previous ignorant or misdirected treatment of patients suffering from an inflamed peritoneum, before they are given into his hands. Ignorance on the part of the laity, isolation, and environment, will always render a certain proportion of cases of peritonitis serious or hopeless. The profession, in general, however, by recognizing that peritonitis is a surgical disease from the start, can do much to lower the mortality and thereby slowly educate the masses to the same understanding.

Treatment.—The treatment of peritonitis is essentially surgical. That it is not necessarily so, is manifested daily by temporary and permanent recoveries under medical treatment, or under no treatment at all, but if we deal with large numbers and consider not the mortality alone, but the morbidity, then there is little question but that modern surgery, properly applied, is a conservative form of treatment.

In local or mild infections the sum of surgical therapy is included in the removal of the infecting focus, followed by drainage or not, as the case may be. Early and direct attack of the infection, minimal disturbance of the surrounding tissues, and intelligent after-care are essential. In subsiding infections delay until the operation can be done as aseptically as within the first hours after onset is good surgery.

To estimate the wisdom of delay requires as good surgical judgment as does the operation itself. We should emphasize this fact in discussing the virtues of the so-called starvation treatment of peritonitis.

Granted that operation is the best treatment in the local, mild, or chronic types, let us consider the treatment in the acute, violent, spreading, or diffuse types which make up the bulk of failures. At the present time, in America, the methods of dealing with these cases may be divided into four groups. First of all, surgeons are unanimous that, given such a case within twelve hours, or at most, thirty-six hours (in appendicitis particularly), the time to operate is at once. After twelve to thirty-six hours, when the sepsis and the peritoneal infection are spreading, we may temporarily withhold interference, trusting to spontaneous subsidence, attenuation of toxins, and localization of infection. Thirdly, we may open the abdomen at once, remove the invading source, if possible, cleanse the cavity by irrigation, and close the peritoneum, draining the muscles and fat layers, or, fourthly, we may open the abdomen, remove the focus with as little disturbance as possible, drain locally, with the patient in the sitting or Fowler position, instilling into the rectum, slowly and persistently, large amounts of salt solution. This is the so-called Murphy method.

Let us take up each of these methods in detail. In the first group, where operation is carried out at the start of the infection, there is but little that we can add to the general technic, as given in Chapter XLII. Such cases are really "interval" cases. The origin of the infection should be removed or otherwise radically dealt with. Thus, an appendix should be excised, a perforation should be closed, an abscess should be drained, etc. All manipulations should be of the gentlest, more so than in true interval cases, because the inflamed peritoneum is very susceptible to injury and infection. Moist wicks and packs, rather than dry, should be used. Because absorption is definitely more slow after a dry than after a wet laparotomy, especially where the peritoneum is at all inflamed, irrigation should not be employed, except in rare instances, as when the visceral contents have been poured forth in quantity. Irrigating fluids should be of the mildest, preferably normal saline solution. Drainage is rarely advisable if the infecting focus is removed. In our experience in these cases we find that the peritoneum takes care of a small residue of sepsis better than the parietal fat, so that we allow for a capillary drain to the parietes in suspicious cases.

The second, or *starvation method of treatment*, is popularly known among Americans as the *Ochsner treatment*. The underlying reason for using this method is that peristalsis spreads peritoneal infection. If all food and cathartics are withdrawn, and if the stomach is emptied of nauseating regurgitated contents, the peristalsis is reduced to a minimum and meteorism is diminished. By this induced rest the peritoneum can dispose of much infection, and an opportunity is allowed for a localization and imprisonment of the infecting origin. In other words the peritoneum is splinted. Once allow a barrier to encompass the focus, in a majority of cases an inflamed appendix or gall-bladder,

and a progressive peritoneal infection is stopped. As soon as isolation is well secured, operation can be done with comparative safety. To carry out this treatment all food by the mouth should be absolutely prohibited. No laxatives nor cathartics should be given. The stomach should be washed out thoroughly one or more times, until that organ is completely freed of the backflow from the upper intestines. Rectal feeding, in amounts not exceeding four ounces, and not oftener than every four hours, will furnish sufficient alimentation. Ochsner maintains that if this is instituted early the most violent and dangerous forms of acute gangrenous or perforative appendicitis become comparatively mild or harmless. It is especially applicable to cases of beginning diffuse peritonitis. There is no doubt but that the general principle of this treatment is a long step in advance in dealing with peritonitis in general. Its specific application requires judgment, and is best used in the hands of surgeons experienced in operating, or in the hands of the general practitioner remote from surgical centers. It is adapted, for the most part, to inflammations of the appendix and gall-bladder; its employment in peritonitis secondary to strangulation, ulcers, etc., implies bad judgment.

The third method of treatment of severe peritonitis, as championed by Blake and others, consists in removal of all active infective foci, thorough irrigation of the abdomen with two-way tubes, until the fluids are returned clean, closure of the peritoneum, and drainage of the muscle and fat layers. The patient is given gastric lavage, when an ounce or two of epsom salts may be left in the stomach. Salines are given by rectum to promote renal elimination, and the patient placed in the sitting or Fowler position. If the infecting necrotic focus cannot be removed, then the peritoneum must be drained on general principles.

The fourth method, as advocated by Murphy, consists in a rapid and gentle removal of the infecting focus, generally an appendix, avoidance of irrigation, sponge cleansing, etc., drainage of the lower part of the cavity through the single incision, or through an additional suprapubic opening, maintenance of the sitting position, gastric lavage, if necessary, for nausea or vomiting, and instillation of normal salt solution into the rectum so gently and steadily that the rectum is not irritated. A large quantity of fluid is thus absorbed, only to be eliminated with the toxins by the kidneys. To accomplish this a short injection nozzle with several small openings is inserted into the rectum and held in place by an adhesive strap about the thigh. To this is connected a reservoir of warm saline solution, elevated only about six to seven inches above the level of the buttocks. This reservoir is replenished and kept warm, so that an adult will absorb, unconsciously, a pint or more within an hour, and this rate can be maintained, if necessary, until he will take care of eighteen pints in the twenty-four hours. The injection is best stopped every few hours for varying intervals if the rectum shows signs of irritation, or when the pulse becomes full.

The last method is being used more and more by American surgeons,

and in my hands it has been most satisfactory. It apparently combats not only the peritonitic process, but the general toxemia as well, and for this reason I make use of it to a modified extent in sepsis from causes other than a peritonitis. I must caution against its over-use. It is possible for a patient to absorb more fluid than can be eliminated, as is shown by a pulse that is over-full in volume or by cough and râles from edema in the lower chest, though these signs are less frequent than after hypodermoclysis. It is better applied to the treatment of

FIG. 386.—THE FOWLER POSITION AND THE METHOD OF GIVING SALT SOLUTION SLOWLY BY RECTUM IN CASES OF PERITONITIS, ETC.
Note the slight elevation of the reservoir.

children than is the Ochsner method. In using the latter I find difficulty in making gastric lavage, and the omentum, upon which we rely for protection in adults, is so poorly developed in children as to be of little practical use.

In addition to the methods described above there are innumerable others, many being modifications of one kind or another. In cases with distention, the gut may be opened in one or more places and emptied of its contents, or the entire length may be stripped or "milked" down to an opening in the distal portion, thus relieving the patient of a

large quantity of poisonous material. The opening of the gut may be closed at once, or an enterostomy may be established by fastening in a glass or rubber tube, or by Stewart's method of introducing half of a Murphy button into the gut and connecting a rubber tube with it by means of the other half. Usually, the cecum or lower ileum is selected for this, but in severe cases it may be best to select any presenting loop. Kocher opens high in the jejunum and low in the ileum, washing the gut through and through and closing the openings at the termination of the irrigation. Most surgeons at the present time avoid the evisceration, wiping with sponges, prolonged or rough handling, and chemical irrigation that have been in vogue at one time or another. All operative procedures tend to grow simpler, to minimize trauma, to rely on peritoneal absorption and destruction of toxins, and on augmenting the eliminative functions of the various organs.

Mikulicz has attempted to institute a hyperleukocytosis by the injection, twelve hours before operation, of 50 cc. of a 20 per cent. solution of nucleic acid. This is aided by flushing out the cavity with hot saline solution. The method apparently is of benefit, but is not yet firmly established.

The efficacy of the Fowler position in securing drainage seems to lack experimental proof, according to Yates and others, but, clinically, the picture is so far different from that which obtained in similar cases under the horizontal or head-low position that few surgeons would willingly return to the old custom at the present time.

The nourishment of patients with peritonitis is best given by rectum or subcutaneously. Enemata should be small in bulk, easily absorbed, warm, and slowly administered. Thirst is controlled best by the saline enemata. Mouth feeding in severe cases with nausea, exudation, or vomiting is a waste of time and energy. The stomach does not absorb, nor does it propel, any food into the intestines, and, beyond sips of hot water, it is best to avoid feeding in the acute stages of peritonitis until nausea and eructations have ceased. This usually comes in forty-eight to seventy-two hours, if the patient survives. At the end of that time the abdominal infection is more or less limited in extent and virulence, and we have to deal with a subacute infection. The tenderness and pain are best relieved by large, thin, hot poultices. Ice applications are rarely as comfortable or effective.

Morphin, to control the severe pain, is useful; at times it relieves the intense spasm of the intestines and acts as a cathartic by allowing peristalsis enough to expel the distending gases. Its routine use, however, must be thoroughly condemned.

Dilatation of the stomach, sudden, acute, and severe, occasionally accompanies an acute diffuse peritonitis, or it may simulate such a peritonitis in the presence of a mild and local infection. Thorough lavage, repeated at short intervals, will turn the progress of the disease as if by magic in such cases.

The use of cathartic enemata has been fully covered in Chapter XLII. So also with stimulants. To emphasize our views we would

repeat that we rely very little on alcohol or strychnin, more on saline enemata, with adrenalin given subcutaneously or in the enemata. Warmth, rest, fresh air, and the Fowler position are necessary, first of all.

The use of continuous intra-abdominal irrigation or of the prone position after operation has not been demonstrated as of definite value.

The question as to whether the infecting focus should always be removed depends upon the severity of the infection, the skill of the operator, and the environment. It is better to save the patient's life by simple drainage, even if the focus is not removed, than to risk a life for the sake of performing a complete operation. Primary eradication may be a most formidable problem; the same operation a few weeks later may be one of the simplest.

After-treatment in septic peritonitis does not differ materially from that after an ordinary laparotomy. Careful watch must be kept for sequelæ, which vary widely. We must look for secondary abscesses, near or remote, in the abdominal cavity, lymphatic infections in the mesenteric and retroperitoneal chains, subphrenic and pleural infections, embolic abscesses of the liver, lungs, heart, etc.; nephritis, phlebitis of the extremities, twists and strangulations, fecal fistulæ, perforation of an abscess into various organs, parietal cellulitis, cutaneous eruptions, acute pulmonary edema, parotiditis, the awakening of latent systemic infections, as malaria, rheumatism, tuberculosis, etc. This is but a partial list of the sequelæ that every surgeon meets sooner or later and with which he must be able to cope. In short, the solution of the immediate problem may be the least serious task that confronts the surgeon when dealing with infectious peritonitis.

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CHAPTER XLVIII.

SURGERY OF THE ESOPHAGUS.

By George Gottstein, M. D.,
BRESLAU.

ANATOMY AND PHYSIOLOGY.

The esophagus begins at the lower border of the cricoid cartilage and, after passing through the hiatus esophagi opposite the body of the eighth thoracic vertebra, enters the stomach 2 or 3 cm. below the diaphragm. The length is from 24 to 28 cm.; the distance from the incisors to the esophageal entrance is 14 to 18 cm.; hence the distance from the incisors to the cardiac end is between 38 and 46 cm. The arteries are branches of the inferior thyroid, posterior bronchial, phrenic arteries, and coronary artery of the stomach. The veins empty into the azygos, superior and inferior venæ cavæ, and portal veins. The nerves are derived from the pneumogastric, laryngeal, and sympathetic. Solid food is carried to the cardia by peristalsis, while fluids are pressed down by the contraction of the mylohyoid muscles (Kronegger and Meltzer). The cardia is provided with a double closing mechanism, a muscular and a valvular, the valves being so arranged as to prevent regurgitation of food from the stomach into the esophagus, but not the passage in the opposite direction.

METHODS OF EXAMINATION.

Percussion, auscultation, palpation, inspection, pressure determination, and radiography are the methods employed. Percussion and auscultation are of minor importance. A deglutition murmur (squirting murmur [5]) is heard soon after the beginning of the act of swallowing, and from six to seven seconds later a second murmur as the food passes into the stomach (squeezing murmur). The second murmur is absent or delayed in partial or complete occlusion at the cardia and when there is a stricture higher up in the gullet.

Examination with a Sound.—The sound or bougie is to be regarded as a prolongation of the examiner's finger and must be introduced very slowly and cautiously, the examiner feeling his way. The following instruments are used for diagnostic purposes: 1, Ordinary soft stomach-tubes of varying thickness; 2, solid flexible bougies (Fig. 387, *a*); 3, fenestrated hollow sounds, sometimes filled with salt or mercury (Fig. 387, *b* and *c*). These may also be used for the introduction of food and have the additional advantage that particles of tumors may lodge in the openings. They may be cylindric or conic, or provided with a conic

tip. In length they vary from 60 to 80 cm., and are made of all degrees of thickness, measured either after Charriere's scale or in centimeters ; 4, Trousseau's whalebone bougie, with detachable olive tips

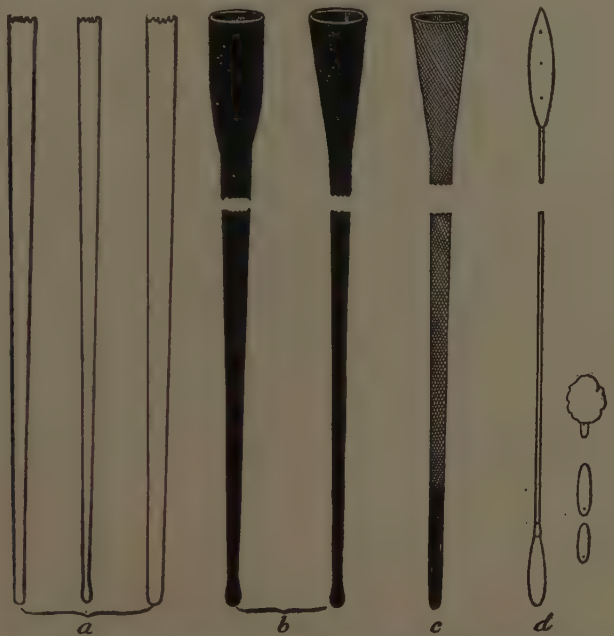


FIG. 387.—*a*, Bougies or sounds; *b*, bulbous sounds; *c*, English rubber sound with funnel and openings at the tip; *d*, Trousseau's olive-tipped bougie.

FIG. 388.—CRAWCOUR'S METAL SOUND WITH SPIRAL.

and of varying thickness and length (Fig. 387, *d*); 5, Crawcour's spiral metal sound provided with a spring (Fig. 388) and of varying

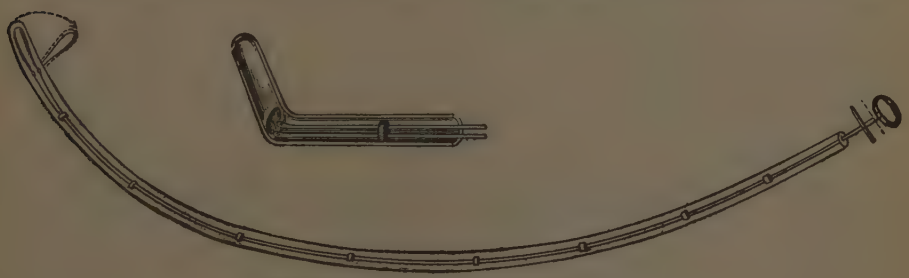


FIG. 389.—LEUBE'S DIVERTICULUM SOUND.

thickness, with conic or round tips. This consists of a long spiral made of rolled tin; 6, diverticulum sound (Figs. 389 and 390), for strictures

situated high up in the esophagus ; an ordinary Mercier catheter may also be used.

For therapeutic purposes the following sounds are also employed: 7, Catgut sounds with rounded ends to facilitate their introduction.

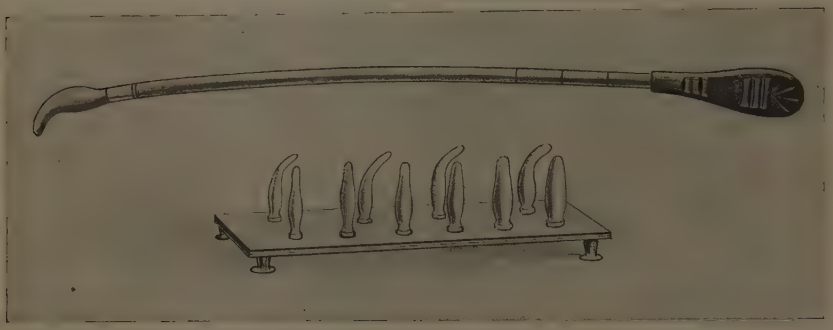


Fig. 390.—Starck's Diverticulum Sound.

The end of the sound swells when introduced into the stenosis and thus effects dilatation; 8, the gyromele and Kuhn's metal spirals; 9, Schreiber's dilating bougie (Figs. 391 and 392). With this instrument dilatation is effected by means of small rubber tubes which can be distended

Fig. 391.—Schreiber's Dilating Sound.

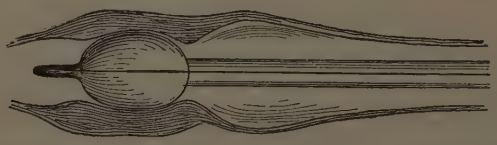


Fig. 392.—Esophageal Stricture. Shows Schreiber's Dilating Sound in Position.

with water. Instruments of this type have also been devised by Reichmann, I. C. Russell, and von Leube ; 10, Senator-Ebstein's swelling

Fig. 393.—Senator's Imbibition Sound with Laminaria Tent.

sounds, soft French esophageal sounds with a thin, detachable laminaria tent (tupelo, pressure-sponge) (Figs. 393 and 394); 11, dilatation by means of a distended drainage-tube (Fig. 395); 12, Eiselberg's tube for

continuous dilatation; 13, tubage of the esophagus (Fig. 398). In this method, hard-rubber tubes of various shapes, from 3 to 5 cm. long and

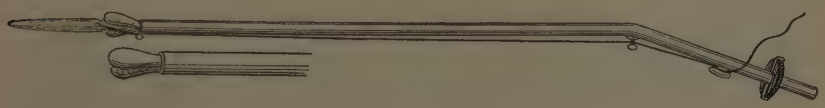


FIG. 394.—EBSTEIN'S INSTRUMENT FOR INTRODUCING LAMINARIA TENTS.

provided with a long silk suture, are introduced into the stricture with an instrument called an introducer, either for the purpose of dilating

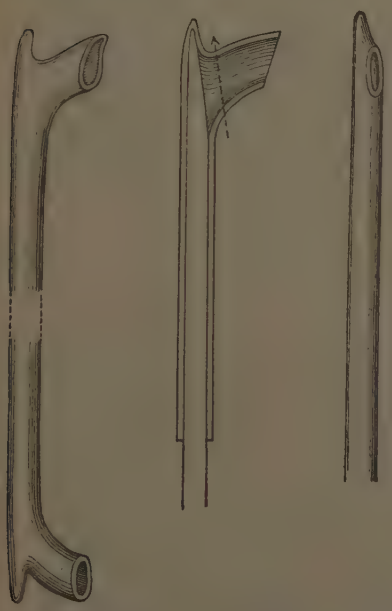


FIG. 395.—VON HACKER'S METHOD OF EXPLORING THE GULLET WITH A DRAINAGE-TUBE STRETCHED OVER A MANDRIN.

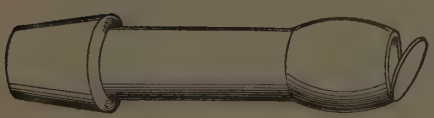


FIG. 396.—GOTTSTEIN'S PERMANENT CANNULA.

FIG. 397.—PERMANENT CANNULA. (After v. Leyden-Renvers.)

the stricture or introducing food through the tube (Fig. 397). For continuous dilatation Gottstein's permanent cannula is used (Fig. 396); 14, Zeehuisen's method: Silver balls of gradually increasing size,

attached to silk sutures, are swallowed and effect dilatation partly by their own weight and partly by the pressure they exert as they are

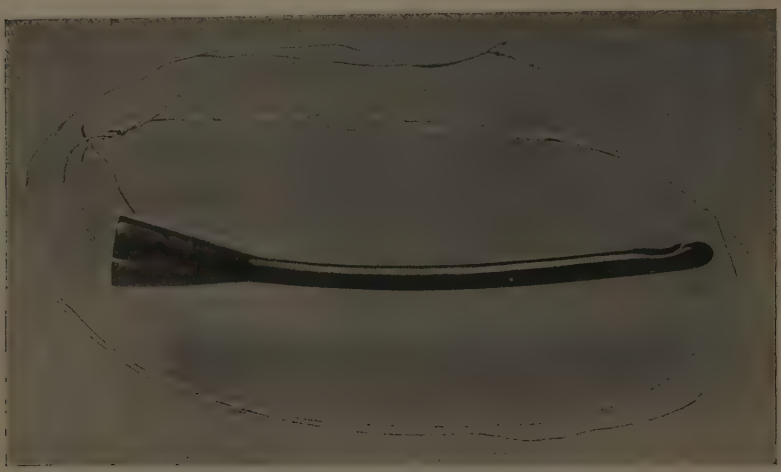


FIG. 398.—SYMOND'S ESOPHAGEAL TUBE.

withdrawn; 15, for von Hacker's method of continuous dilatation, see the chapter on Methods of Operation.

FIG. 399.—METHOD OF INTRODUCING ESOPHAGEAL BOUGIE.
The bougie is bent before it is introduced.

Technic.—The object of introducing a sound is to determine the seat of the stenosis, its nature, and the degree of constriction. Before introducing a sound false teeth must be removed from the mouth. On

account of the copious flow of saliva the patient should hold a basin in both hands and should be instructed to breathe in and out rapidly during the examination, to avoid retching, to allow the saliva to flow from the mouth into the basin, and not to grab at the sound with his hands, as such a procedure may be very dangerous. Before a sound is introduced for the first time the vascular system should be thoroughly examined.

Contra-indications.—Acute inflammation of the esophagus; during the first four to six weeks after a burn; recent hemorrhage from the esophagus or stomach; advanced pulmonary or cardiac disease; aortic aneurysm; advanced cirrhosis of the liver. According to the author's method the sound is first dipped in warm water or oiled

FIG. 400.—METHOD OF INTRODUCING ESOPHAGEAL BOUGIE.
Position I.: The head in extension until the bougie reaches the esophageal entrance.

and introduced as shown in Figs. 399, 400, and 401. If the pharynx is very sensitive it should be touched with a 10 per cent. solution of cocain. In examining children a wooden wedge must be inserted between the teeth to protect the sound. Pressure with the sound is strictly forbidden. For measuring the depth of the stenosis a graduated sound, or von Mikulicz' measuring sound, is used.

The successive steps in an examination with the sound are as follows: A thick, soft stomach-tube is first introduced, and if, after waiting a few minutes, it passes the stenosis, the latter is usually due to spasm; if not, the condition may be an organic stricture, a diverticulum, or spasm. If the introduction of the tube causes local pain there may be a tumor, an ulcer, or an esophagitis. If no contraction is felt on the tube there may be atony, or paralysis, or disturbance of sensation; if

the tube can be moved slightly in different directions, a dilatation may be assumed to be present. After withdrawing the tube, the openings

FIG. 401.—METHOD OF INTRODUCING ESOPHAGEAL BOUGIE.
Position II.: The chin brought down almost to the chest; the bougie glides into the esophagus.

should be examined for the presence of particles of tumor, blood, or pus. If a thick stomach-tube can be passed into the stomach, stenosis of the esophagus can be excluded with a fair degree of probability. In order to determine the degree of stenosis a hard esophageal or olive-tipped sound is introduced. It is best to begin with cylindric sounds, then to try a conical sound; finally by using successively thinner sounds the degree of stenosis can be determined. In cases of spasm thick, cylindric sounds are used. In many cases the diverticulum sound will be found useful. Any swelling that may be produced by the passage of a sound subsides in a few days. If the stenosis offers great resistance to the passage of a sound, from 6 to 8 small catgut sounds are used, as in the case of urethral strictures. To facilitate the introduction of the catgut sounds a hollow sound may be used (Fig. 402). In severe degrees of stenosis the belching of gas and regurgitation of food will serve to indicate that the stricture is still permeable.

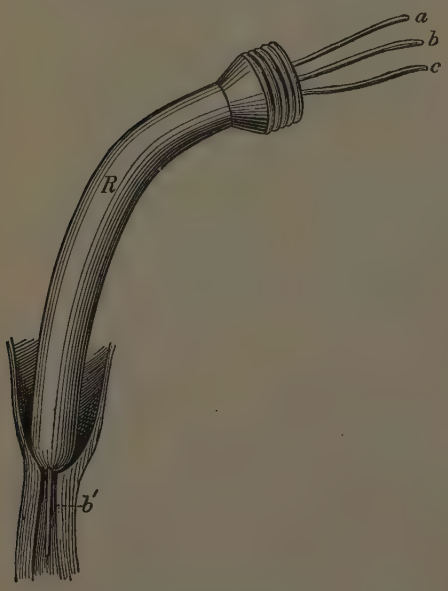


FIG. 402.—VON HACKER'S METHOD OF INTRODUCING THIN CATGUT BOUGIES.
(*a*, *b*, *c*) Into the stricture (*b'*) through a wide hollow bougie (*R*).

The Passage of Sounds for Therapeutic Purposes.—In cases of mild strictures cylindric sounds are preferred. If the stenosis is pronounced, a conical bougie is necessary. Patience, skill, and practice on the part of the physician as well as the patient are necessary for the performance of a successful therapeutic sounding. By means of delicate movements of the wrist, the sound must be gently turned to the right, to the left, forward and downward, until it enters the stricture; frequently a twisting movement of the sound is necessary to effect an entrance. For very close strictures Kraus advises the introduction of a thick sound, which is pressed against the face of the stricture for a few minutes, after which a thinner sound is quickly introduced. This sound is left in place for from ten to fifteen minutes and, if it passes

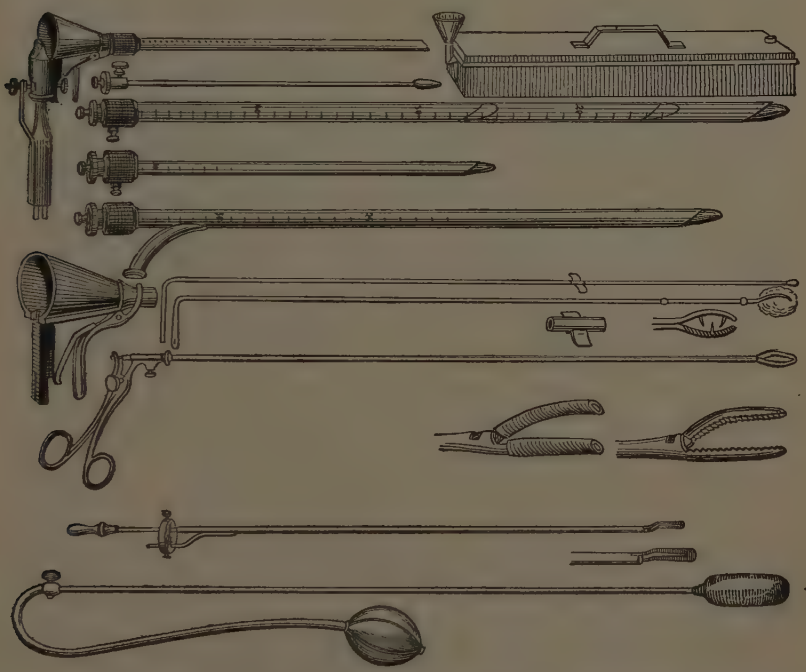


Fig. 403.—Von Mikulicz Set of Instruments for Esophagoscopy.

easily, the next size is at once introduced. Cancerous strictures should be treated daily. Intelligent patients learn to pass the sounds on themselves, the best for this purpose being a stomach-tube filled with mercury. A sound should not be passed after a recent burn. On the other hand, cicatricial and cancerous strictures are indications for the introduction of sounds.

Esophagoscopy.—The greatest advances in the diagnosis and treatment of diseases of the esophagus have been made possible by direct inspection or esophagoscopy. Attempts to develop an indirect method of inspection by means of a laryngeal mirror proved futile. Von

Mikulicz was the first to lay the foundation of modern esophagoscopy by employing rigid tubes and direct inspection.

Von Mikulicz's instrument set (Fig. 403) consists of straight rigid tubes, from 10 to 14 mm. thick, beveled at the lower extremity. The outside surface of the tube is covered with a centimeter scale 26, 36, 46, or 50 cm. in length, and the inner surface is covered with lacquer. To facilitate introduction a metal mandrin, the lower end of which is solid and beveled, is pushed into the tube.

Fig. 404.—Esophagoscope with Guide.

In order to overcome the difficulty of passing the inferior pharyngeal constriction I now almost invariably use a flexible guiding sound of twice the usual length and 3 mm. in thickness (Fig. 404), over which I introduce the tube with a hollow mandrin. The illumination is best effected by means of a Casper panelectroscope. The prism of the panelectroscope is provided with a funnel which fits into the tube and permits the ready introduction of instruments. In addition the set comprises a number of cotton applicator sounds of various lengths, forceps, and an apparatus for warming the instruments preparatory to their introduction.

Preparation of the Patient.—Except in cases of emergency, the examination should be performed when the stomach is empty. Sometimes it must be preceded by lavage, as, for example, in cases of dilatation of the esophagus. The seat of the obstruction should be known beforehand in order that as short a tube as possible may be employed. The structures of the mouth and pharynx, including the entrance to the esophagus, should be thoroughly anesthetized with a 10 per cent. solution of cocain.

Position of the Patient.—After the example of von Mikulicz, I examine in the lateral position. Others use the recumbent or the sitting posture. The patient lies on an operating table which can be raised or lowered at will. The head is supported by an assistant, who must follow all the movements of the examiner (Fig. 405). Before the tube is introduced the patient is enjoined, first, to breathe quietly; second, since he cannot speak, to raise his left hand if he feels severe pain; third, not to attempt to stop the flow of saliva. Tight-fitting clothing and artificial teeth must be removed.

The assistant first bends the head forward, and the guiding sound, well oiled, is introduced. The head is then bent backward, and the tube with hollow mandrin, which has been previously well oiled, is introduced over the guiding sound (Fig. 406). As the patient swallows, the tube glides into the esophagus of its own accord. After the con-

strictor has been passed, the guiding sound and hollow mandrin are removed, the illuminating apparatus is attached, and the tube is pushed farther into the esophagus under direct inspection. Anything like force during the introduction must be absolutely avoided. In the case of

FIG. 405.—POSITION OF PATIENT DURING ESOPHAGOSCOPY. (After v. Mikulicz.)

children a general anesthetic is sometimes necessary, and since the introduction of the guiding sound this can be administered without danger. The pain in the region of the larynx, which almost always follows an examination, can be relieved with an ice cravat, ice pills, eating of ice cream, morphin, or cocain.

FIG. 406.—INTRODUCING ESOPHAGOSCOPE OVER A GUIDE.

By means of esophagoscopy we may detect the presence of foreign bodies and remove them; we can diagnose inflammations, ulcerations, tumors, dilatations and diverticulæ, cicatricial stenoses, etc.; particles of tumors can be removed for microscopic examination; and, for the

purpose of overcoming a stenosis, fissures can be cauterized, or partial strictures dilated with suitable instruments. The contra-indications for the employment of esophagoscopy are the same as for the introduction of a sound in general.

Killian and Gottstein have constructed models which may be used for practicing esophagoscopy and bronchoscopy (Fig. 407).

The Esophagoscopic Picture in the Normal Esophagus.—The mucous membrane is pale-red, sometimes transversely striated in the thoracic portion. At the cardia it merges by a zigzag line with the deep-red, velvety mucous membrane of the stomach. The lumen in the cervical portion is closed—the mucous membrane forms a rosette—in the cervical portion it is wide open, and sometimes one can see as far as the hiatus of the esophagus, or even into the stomach. The lumen in some places is semicircular, in others crescentic or oval. The infra-bifurcal portion is the widest. At a distance of from 35 to 38 cm. from the teeth the hiatus is seen as an oblique slit. The cardia is closed and

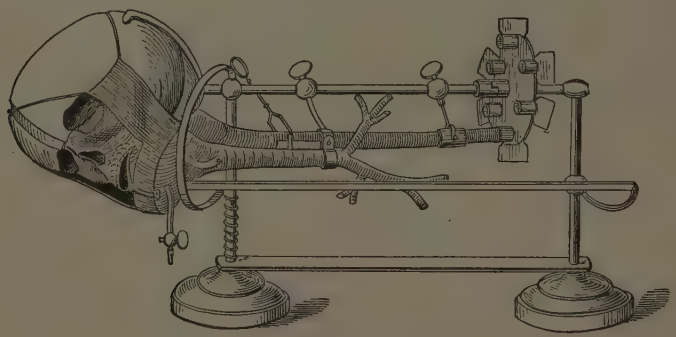


Fig. 407.—Gottstein's Model for Esophagoscopy and Bronchoscopy.

presents the appearance of a rosette; a deep inspiration often opens it to the size of a lead-pencil. If the tube enters the stomach, the view is obstructed by a trabecular, dark fold of mucous membrane. We distinguish respiratory, pulsating, and peristaltic movements; but the first are the most important because their absence indicates a pathologic condition. The pulsating movements are caused by the proximity of the aorta and of the heart, and are frequently transmitted directly to the tube. Peristaltic movements in the form of slight oscillations, or complete contraction waves, are noted during deglutition and the act of vomiting. The normal esophagus contains neither mucus nor food remains.

Pressure Determination.—In motor disturbances, spasm, and paralysis of the esophagus, von Mikulicz determined the pressure by means of the air and fluid method (warm or cold Seltzer water), using the apparatus shown in the accompanying figure (Fig. 408). Marked deviations from the normal are observed, especially in cases of spasm and paralysis of the esophagus. In cases of cancerous stenosis the pressure is different from the pressure in cicatricial strictures.

Radiography.—Foreign bodies in the esophagus, especially metal bodies, can almost always be detected with a fluoroscope or a skiagraph. The rays should enter obliquely from the right side behind to the left side in front (Holzknecht's fencing position). The position of the stenosis and any change in the act of deglutition can also be detected by having the patient swallow capsules of bismuth (0.25 to 2.0 grammes—4 to 30 grains of bismuth). In order to recognize dilatations or diverticula, the patient is made to swallow a porridge of bismuth and potato (from 20 to 50 grammes—5 to 12½ drachms—with sugar), when a distinct shadow is seen. Bends in the esophagus and adhesions can also be rendered visible by the introduction of bismuth or mercury sounds. Sometimes the presence of diverticula or dilatations is discovered by the kinking of the bismuth or mercury sounds. On examining the patient with a fluoroscope in the fencing position, tumors are sometimes seen as slight shadows between the shadow of the vertebral column and that of the aorta. Aortic aneurysm can also be diagnosticated, although tumors of the esophagus, when adherent to the aorta, may pulsate forcibly and simulate an aortic aneurysm. Compression tumors of the aorta can also thus be recognized.

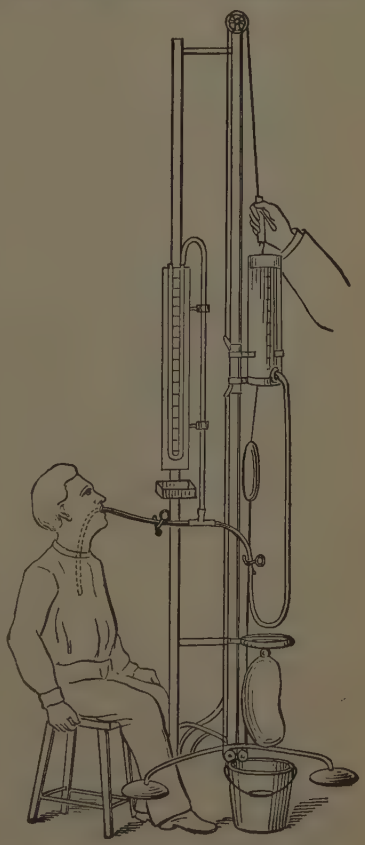


FIG. 408.—APPARATUS FOR DETERMINING THE PRESSURE IN THE ESOPHAGUS.

CONGENITAL MALFORMATIONS.

These are extremely rare and have no surgical interest. Death usually occurs in the first week of life.

Congenital esophagotracheal fistula and partial obliteration are also rare, but as the children survive, they have some clinical significance.

The symptoms consist in attacks of asphyxia during deglutition. Fluids either regurgitate through the nose and mouth, or enter the trachea and produce severe dyspneic attacks which may even end fatally.

Malformations of the esophagus are frequently associated with other malformations which render life impossible (35 per cent.). If this is not the case, life may be saved by means of a gastrostomy; or a

radical operation may be considered later on. When the condition consists simply of a membrane (diaphragm), which can be determined by means of a radiograph after introducing metal sounds from above and from below, the membrane is simply perforated with a Murphy button or by electrolysis. Communication with the trachea does not constitute a contra-indication. Recently it has even been suggested to close the fistula in the Sauerbruch chamber. Congenital stenosis and dilatation will be discussed later.

INJURIES OF THE ESOPHAGUS.

Injuries of the esophagus from within are common and are caused by foreign bodies or by instruments, especially in cases of stricture and ulceration. On the other hand, injuries from without, shot wounds, stab wounds, or incised wounds are extremely rare, and when present are usually associated with injuries to neighboring organs which endanger the patient's life. Occasionally a shot or stab wound, however, may injure the esophagus alone, and such a wound may heal even after food particles have escaped through the opening for a long time. When the wound is situated in the thoracic portion, however, death usually occurs from mediastinitis.

Symptoms.—The characteristic sign is the escape of food through the external wound, although this may be absent even in stab wounds or shot wounds of the esophagus when the edges of the wound are in close apposition. In cases of true esophageal fistula the condition is occasionally revealed by the spasmodic cough which follows the act of swallowing; or the diagnosis may be made by Gerhardt's method.

The prognosis in injuries confined to the esophagus is not unfavorable.

Treatment.—Congestion must be avoided. After dilating the wound and undermining the edges in layers, sutures are introduced and the wound is packed with gauze. In the case of injuries of the thoracic portion, the operation in Sauerbruch's chamber, cervical mediastinotomy, or packing through the esophagoscope are the procedures to be considered. In any case the patient must be fed exclusively by the rectum, by the stomach-tube, or by means of a gastrostomy.

WOUNDS OF THE ESOPHAGUS.

Rupture is very rare. It may follow an injury or occur spontaneously during vomiting after a very full meal, or during lavage. The cause of spontaneous rupture is believed to be an esophageal malacia, produced by hyperacid gastric juice in conjunction with a marked increase of the internal pressure. In my opinion spasmodic closure of the inferior constrictor of the pharynx is necessary before rupture can take place. In the cases that have been observed so far (about 20) the tear was longitudinal and situated in the region of the cardia or above that point. In only 1 case was the rupture transverse. All the patients were males and most of them alcoholics.

Symptoms.—The symptoms always come on suddenly, with retching

and vomiting, accompanied by severe pain in the chest and epigastrium. Further vomiting is impossible, and fluids pass without difficulty. Death occurs within twenty-four hours, with collapse, dyspnea, and the rapid development of cutaneous emphysema in the neck. The **treatment** is symptomatic. An operation in Sauerbruch's chamber might possibly prove successful.

Perforation.—Primary perforation into neighboring organs occurs in the last stages of diseases of the esophagus. Perforation occurs particularly into the large vessels, the lower air passages, the mediastinum, etc.; in cases of stricture, ulcerations, foreign bodies, and traction diverticula. The perforation usually develops gradually. In benign cases recovery has been observed. Secondary perforation results from rupture of diseased neighboring organs into the esophagus, as, for example, aortic aneurysm, destructive processes affecting the cervical and thoracic organs. The diagnosis is sometimes difficult. If there exists a communication with air conducting organs, the expectoration of particles of food is of assistance; or the diagnosis may be made by Gerhardt's method. This consists in the introduction of an esophageal tube into the esophagus, when a current of air will pass through, especially noticeable when the external end of the tube is held under water.

Treatment.—Rectal feeding, gavage, or gastrostomy, if there is any prospect of the operation proving successful.

Hemorrhage.—When due to perforation of large vessels, hemorrhage almost always proves fatal. It may occur in carcinoma; as the result of foreign bodies; in perforation; aneurysm; burns of the esophagus; from the rupturing of varices; in cirrhosis of the liver; in ulcerations, etc. If the hemorrhage is slight there may be no symptoms whatever. Severe hemorrhage causes tarry stools and hematemesis. The source of the hemorrhage, whether gastric or esophageal can be determined, if at all, only with the esophagoscope. The **treatment** is symptomatic: ice pills, adrenalin, styptol, ergotin, and rectal feeding. It may be necessary to search for the bleeding spot with the esophagoscope and pack with gauze, with an inflated rubber bulb, or a Schreiber dilatating bougie.

FOREIGN BODIES IN THE ESOPHAGUS.

Foreign bodies of the most varied description get into the esophagus from the mouth and are particularly apt to become impacted in strictures. Among the most common are false teeth, which get into the esophagus during sleep and in general anesthesia along with particles of food. In industrial workers, needles and nails; abnormally large mouthfuls of food, pieces of bone, fruit stones, fish bones; and, in children and insane persons, coins, toys, etc. The foreign bodies burrow into the mucous membrane and cause complete or partial occlusion of the lumen. The favorite seats are at the inferior constrictor of the pharynx, above the bifurcation, and above the hiatus esophagi. Small foreign bodies, especially sharp pieces of bone, fish-bones, and splinters

of wood may lodge anywhere in the esophagus. Most foreign bodies are seen above the bifurcation. They are seen directly above the cardia only when they have been artificially wedged fast with instruments, as, for example, during an examination with a bougie. The symptoms vary according as the foreign body has produced an injury, or occlusion, or both. If the esophagus is occluded high up, attacks of asphyxia may occur; if the foreign body is soft, death may ensue. When the occlusion is situated above the bifurcation, food and saliva are regurgitated with retching immediately after being swallowed; if the occlusion is below the bifurcation, regurgitation is delayed for some time. If the foreign body has injured the mucous membrane, the chief symptom is a stabbing pain. The localization of the pain does not

FIG. 409.—SKIAGRAPH SHOWING TOY BICYCLE LODGED IN THE ESOPHAGUS. (Rigby.) Successfully removed by esophagotomy.

always correspond to the seat of the foreign body. In most cases the patient complains of a feeling of pressure, although sometimes even large foreign bodies, such as dental plates, may remain for years in the esophagus without attracting attention. Even after the foreign body has passed the patient sometimes complains of pain, which is due to injury. Even when there is not complete obstruction, regurgitation may occur as the result of spasm. Mucus and blood indicate an injury. Larger quantities of blood are usually regurgitated only days or weeks after a foreign body has been swallowed and has lodged in the tube. Fatal hemorrhage occurs chiefly when the foreign body is sharp. Objects of this kind always produce severe signs of inflammation, local abscess, decubital ulcers, perforation into the air passages, mediastinitis, and pyemia.

The **diagnosis** is made by the history and subjective symptoms, with the additional aid of examination with a sound, radioscopy, and esophagoscopy. Examination with a sound is in general to be condemned. Even in the most favorable case it reveals only the level of the foreign body, and in many cases the deceptive ease with which the sound glides along the esophagus causes the foreign body to be overlooked. Even when the foreign body can be felt with the sound, the examiner is often deceived in regard to its position, and in many cases the examination does harm by causing impaction or by pushing the object from the suprabifurcal into the infrabifurcal portion and causing it to lodge at the cardia. Examination with the sound should be

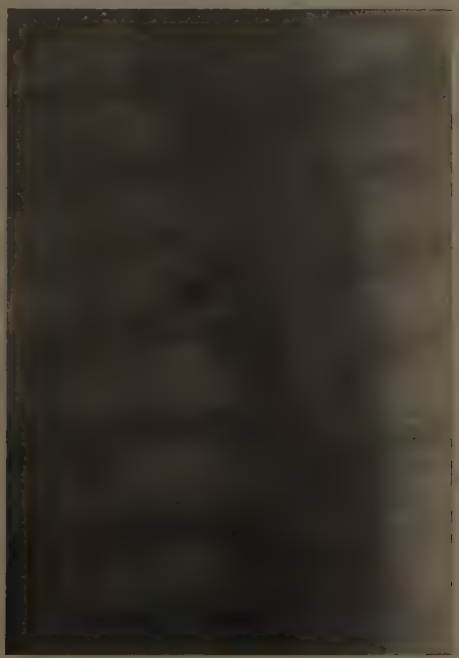


FIG. 410.—TOOTH WITH A SMALL PIECE OF PLATE ATTACHED.
The patient was a girl twenty-one years of age.

resorted to only in the case of soft foreign bodies, as in such a case the object may be pushed into the stomach by the sound, or the irritation incident to the introduction of the sound may induce vomiting and cause the foreign body to be ejected.

Radioscopy proves successful only when the foreign body consists of metal, rubber, or some other substance that throws a dark shadow. By means of transillumination and photography, in the fencing position, even a very small part of a dental plate can always be detected (Figs. 410 and 411). Before the introduction of these methods it was not always possible to detect the presence of false teeth.

The best method, both for diagnosis and treatment of foreign

bodies in the esophagus, is esophagoscopy. The successive steps of the examination are as follows: First, it is ascertained positively whether the foreign body has been swallowed or aspirated, or whether it is hidden in the folds of the clothing in the patient's bed, as often happens in the case of nervous people. Next, the shape, size, and nature of the foreign body are ascertained by external inspection, palpation of the neck, of the mouth, of the pharynx, and by means of a laryngoscopic examination. This is followed by radioscopy: First, transillumination with sulphide of zinc and then photography. The last step in the examination is esophagoscopy, which offers the only reliable means of making a diagnosis.

Treatment.—The treatment of foreign bodies is not begun until after the diagnosis has been positively established.

Bloodless Methods.—If there is danger of asphyxia, the foreign body may often be removed at once by inserting the fingers into the throat. If necessary a curved pharyngeal forceps may be used. In

FIG. 411.—TOOTH WITH PIECE OF PLATE 0.8 BY 1.2 CM.

The foreign body was located with the Roentgen rays and seen with the esophagoscope, introduced over a guide. The dilatation of the gullet, incident to the introduction of the esophagoscope loosened the foreign body, which was carried into the stomach by peristalsis and discharged per rectum twenty-four hours later. The patient was a girl, twenty-one years of age.

cases of emergency tracheotomy must be performed. Emetics must be avoided altogether, because they usually have the effect of wedging the foreign body more tightly than ever.

Artificial digestion or the induction of shrinking with hydrochloric acid and pepsin or a solution of papain with dilute hydrochloric acid: In a few cases I have succeeded in causing shrinking of a foreign body by having the patient drink strong cognac, after which the body passed into the stomach. Extraction through the mouth with pharyngeal and esophageal forceps, especially those designed by Gutsch and Eckholdt (Fig. 412), with a Weiss fish-bone extractor, or a Gräfe coin catcher (Fig. 412). These instruments are now rarely used, except when the foreign body is impacted at the entrance to the esophagus. *Removal by pushing the body into* the stomach is indicated only when the esophagus is normal and the foreign body is soft. Removal through the esophagoscope, either by way of the mouth or by forcing the object into the stomach, usually succeeds, and is best performed under cocain anesthesia; in the case of little children a general anesthetic is required. The use

of the guiding sound is usually avoided; if, however, esophagoscopy is impossible without the guiding sound, the latter may be used (even when the foreign body is small, Figs. 410 and 411), as the thin soft sound does not dislodge the foreign body from its position. Soon after the cricoid cartilage has been passed the esophagus is carefully searched from above downward. Small foreign bodies sometimes escape detection until the esophagoscope is withdrawn, or they may be felt as the tube passes over them. Sometimes the dilatation effected by the introduction of the tube, or the peristalsis which is set up, suffices to loosen the foreign body and propel it into the stomach (Fig. 410 and 411). If not, the foreign body must be brought into the field and, after being loosened with suitable instruments, such as forceps,

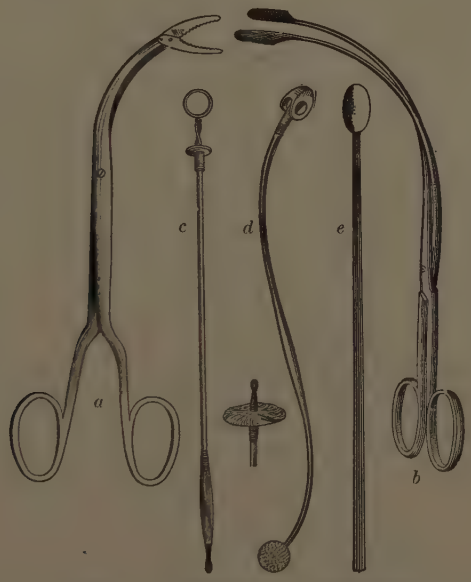


FIG. 412.—ESOPHAGEAL INSTRUMENTS.
a, *b*, Forceps; *c*, horsehair probang; *d*, coin-catcher; *e*, esophageal bougie.

hooks, and the like, either extracted through the tube, or, if it is too large, along with the tube, or pushed into the stomach. Foreign bodies situated above the bifurcation are best extracted through the mouth; when situated below the bifurcation the foreign body should, if possible, be made to glide into the stomach. When a foreign body is impacted, morcellation with the galvanocautery is sometimes necessary. If the mucous membrane around a foreign body that has been lodged fast for some time is swollen, the swelling must be reduced by the application of adrenalin. If there is much mucus, it must be removed with the mucus aspirator, or cautiously taken up with cotton swabs. If it is positively known that there is a foreign body in the esophagus, and it cannot be seen, there is some error in the examiner's technic.

The removal of foreign bodies from strictures may present great

difficulties, particularly when the foreign body is small. In such a case the application of adrenalin is helpful. Sometimes there are two strictures, and the foreign body may be situated in the lower stricture, although the tube is unable to pass the upper. In such a case the upper stricture should first be dilated with a laminaria tent. Up to 1905, 78 cases of esophagoscopic foreign bodies were published. Von Hacker has successfully removed foreign bodies from a normal esophagus 18 times, and 17 times from strictures. In only one case did he fail to remove the foreign body from a stricture and was compelled to resort to gastrostomy. In the Breslau clinic, out of 154 cases of suspected foreign bodies observed during a period of ten years, 53 were subjected to esophagoscopy; in 19 of these the foreign body had already passed; and out of 34 cases the object was successfully extracted in 29. In 8 of them the foreign body was lodged in a stricture.

Operative methods are indicated only when bloodless methods fail; when there are symptoms of perforation; or in the presence of severe hemorrhage that would make it impossible to see anything with the esophagoscope. We perform esophagotomy when the foreign body is situated above the bifurcation. When the body is lower down in the esophagus, esophagotomy and gastrotomy are the methods to be considered; but the former very often fails. The incision is usually made on the left side; the right side is selected only when the foreign body is felt, or signs of phlegmonous inflammation are present on that side. In making the esophageal incision, we cut down directly on the foreign body, or, if it cannot be felt, on the tip of a previously introduced esophageal sound. Extraction is performed with curved dressing forceps; if necessary, the foreign body may be broken up with bone forceps.

In performing gastrotomy the stomach is either sutured to the abdominal wall, or the viscus is drawn out through the abdominal wound, the surrounding structures walled off with gauze pads, the stomach incised, and the entire hand introduced; or a smaller incision is made for the introduction of instruments. Instead of an instrument, the finger may be tied into the stomach by means of a purse-string suture, the wall of the stomach invaginated into the esophagus, and the body extracted with the hooked finger. If the "suture method" is to be employed, it must be possible to force a thin probe past the foreign body; to this a sponge is attached and, as the sponge is withdrawn, the foreign body is carried down with it. Out of 19 cases gastrotomy proved successful in 15.

Complications of Foreign Bodies in Esophagus.—The most frequent is hemorrhage, which occurs when the foreign body is wedged fast. If the bleeding is profuse, attempts should be made to ligate the eroded vessels; if the bleeding spot cannot be found, the carotid must be ligated in the lower third.

Perforation of the foreign body into the surrounding structures may cause empyema, pyopneumothorax, or abscess. Evacuation is effected by operation, and the foreign body may even be removed. In cases of abscess the prognosis is unfavorable. We distinguish between cervical

and thoracic abscesses; the symptoms are moderate fever and sometimes chills. Cervical abscess causes marked swelling of the pharynx, pain during movements of the head and deglutition, and a doughy swelling in the neck. Cutaneous emphysema is a very unfavorable sign. In abscess of the thoracic portion symptoms may be entirely absent with the exception of slight interference with deglutition and moderate fever (37.5° to 38.5° C.—99.5° to 101.3° F.).

Treatment.—*Cervical* mediastinotomy: Of the cases that have been subjected to the operation 5 ended in recovery and 2 were fatal. Posterior thoracic esophagotomy, which is employed when the foreign body cannot be removed in any other way, offers but little prospect of success; of 3 cases in which this operation was performed one survived after an illness of nine months.

INFLAMMATIONS AND ULCERATIONS.

Acute Inflammations.—We distinguish inflammation produced by mechanical, chemical, and thermic causes (foreign bodies, chemical burns, scalds, sharp particles of food, etc.), and the inflammations which follow acute infectious diseases.

Toxic (corrosive) esophagitis, the most important from a practical standpoint, is caused by the swallowing of corrosive chemicals (solutions of caustic soda, lye, acids, etc.). We distinguish superficial corrosion, with desquamation of epithelium, sometimes in the form of casts, and deep corrosion, which may cause perforation into surrounding structures. Corrosions due to concentrated chemicals almost always end fatally from perforation of the stomach or erosion of the windpipe. The symptoms vary with the severity of the injury from slight interference with deglutition to severe conditions of collapse. The diagnosis is made by the history and the discovery of eroded areas in the mouth. In all severe cases the prognosis is doubtful.

Treatment.—Immediately after the injury a stomach-tube should be introduced, avoiding pressure, and the esophagus flushed out with water, oil, or milk; in the case of acids, with soap solution, and in the case of lye, with thin vinegar or citric acid; or the patient may be made to drink milk, oil, etc. Emetics are not to be used. The rest of the treatment is purely symptomatic—ice, rectal feeding, opium, etc. In recent, severe corrosions, and in acute occlusion due to secondary swelling, immediate gastrostomy is to be recommended, which, after six weeks, may be utilized for continuous dilatation. When the pylorus is also affected, von Hacker recommends duodenostomy. During the first four to six weeks the introduction of a sound is absolutely contraindicated; also when there is fever, or the saliva or vomitus contains blood.

Acute catarrhal inflammation occurs after the swallowing of foreign bodies, the careless introduction of sounds, the ingestion of hot and irritating fluids and, rarely, as an idiopathic disease, particularly after excessive indulgence in alcohol. The symptoms consist in high

fever, severe pain on swallowing, retching with the production of a tenacious secretion, pain on moving the neck, speaking, etc.; during pressure on the esophagus, and whenever a change of posture is made. Esophagoscopy and the introduction of sounds ought to be avoided unless there are foreign bodies wedged fast. The prognosis is good.

Treatment: Absolute rest, rectal feeding, morphin, tannin. Recovery occurs in from three to fourteen days.

Phlegmonous Esophagitis.—The causes are: foreign bodies, corrosions, phlegmon of the stomach, rupture from peri-esophageal purulent foci, and lacerations of the mucous membrane after violent vomiting. We distinguish a diffuse and a circumscribed form. The diagnosis is difficult, and the esophagoscope is of use only when the inflammation is caused by the presence of a foreign body. The symptoms are fever, chills, dysphagia, dyspnea, and the expectoration of pus. In the diffuse form the prognosis is unfavorable. In the circumscribed, it is doubtful.

Treatment: When the diagnosis has been confirmed by inspection with the esophagoscope, the abscesses should be punctured, or the mucous membrane incised. Spontaneous perforation sometimes occurs. Mention should also be made of exfoliating and fibrinous esophagitis after diphtheria, smallpox, etc.

2. **Chronic inflammatory processes** either result from acute inflammation or may be chronic from the outset. Chronic esophagitis is particularly frequent in alcoholics and smokers; in association with chronic pharyngitis, and gastric catarrh; in the mucous membrane immediately above an old stenosis; in dilatation and in diverticula; in association with ulcer of the stomach; and secondarily, as an accompaniment of severe congestion following cardiac or pulmonary disease. Leukoplakia of the esophagus, which closely resembles the same condition in the mouth and predisposes to carcinoma, is sometimes associated with the chronic catarrh. The symptoms are slight interference with deglutition and burning in the esophagus.

After acute infectious diseases (typhoid fever, scarlet fever, diphtheria, small-pox, sepsis) we may have the formation of fibrinous false membranes, infiltration, and in consequence of these processes, scar formation. Thrush is found most frequently in children, but also in debilitated individuals. Beginning in the mouth, it often extends deep into the tissues and may even give rise to metastases in the brain. The diagnosis is made with the microscope; sometimes particles caught in the openings of the fenestrated sound may be utilized for examination.

Treatment.—Mechanical cleansing, irrigation with 3 per cent. borax solution, emetics, etc.

3. **Ulcers.**—Catarrhal erosions and ulcerations occur in association with chronic catarrh.

Treatment.—Local applications of silver nitrate through the esophagoscope; bismuth.

Fissures are observed after the swallowing of foreign bodies and also within cicatricial strictures. They sometimes give rise to spastic states. The seats of predilection are the entrance to the esophagus

and the cardia. The symptoms are cramp-like pains during eating and when the sound is introduced.

Treatment.—Local applications of silver nitrate or bismuth; rectal feeding; cocain, temporary gastrostomy. Ulcers due to pressure—gangrene—are produced by the pressure of foreign bodies, permanent dilating sounds, and aortic aneurysm. Decubital ulcers the size of a penny are seen on each side of the anterior and posterior wall, and are due to the pressure of the plate of the cricoid cartilage; they occur at the entrance to the esophagus in bedridden and greatly emaciated patients.

MOTOR DISTURBANCES OF THE ESOPHAGUS.

We distinguish hyper- and hypokinetic disturbances. The term hyperkinetic is used to describe spastic contractions of the muscles exceeding in intensity the physiologic normal. Depending on the location, we speak of esophagismus or cardiospasm; and to indicate whether the disturbance is functional or organic, the terms idiopathic or primary, and secondary spasm are employed.

Esophagismus.—Idiopathic spasm of the esophagus (esophagismus) is common. It may occur anywhere in the esophagus, but especially in the highest portion. The spasm occurs in smokers and drinkers, in nervous persons (globus hystericus), in women, and in small children. As a rule, it occurs only in paroxysms. Chronic forms persisting for years, in which the autopsy fails to reveal alterations of any kind, not even a dilatation above the seat of spasm, are mentioned by Kraus.

According to the etiology we distinguish three varieties: 1. A form occurring as a symptom of some well-defined clinical picture, as that of rabies, tetanus, hysteria, epilepsy, chorea (also typhoid fever). 2. A reflex form produced by irritation in some other part of the body. 3. An idiopathic form. The symptoms consist in dysphagia and, sometimes, severe cramp-like and colicky pains in the chest, radiating to the shoulder. Fluids sometimes pass the obstruction, but occasionally even the swallowed saliva is arrested. The dysphagia usually comes on suddenly, but sometimes develops gradually. The frequent changes in the degree of permeability to food is a characteristic sign. Objectively the sound meets with resistance at the seat of the spasm, which resistance disappears after waiting a few seconds or minutes and after employing greater force. The sound sometimes transmits the sensation of passing a narrow canal. The diagnosis of the condition itself is confirmed by esophagoscopy which, however, fails to reveal the primary disease; for below the point of spasm there may be an ulcer, a fissure, a stricture, or a tumor. The manner in which the mucous membrane closes up in front of the tube is characteristic; a firm and rosette-like appearance is presented, and the lumen remains unchanged. There is no dilatation above the seat of spasm. The diagnosis is favorable, but there is a great tendency to recurrence.

Treatment.—Rest, cocain, morphin, systematic use of sounds, gavage, the constant current, bromids; sometimes rectal feeding; possibly gastrostomy.

Cardiospasm may be acute or chronic. The acute form produces the same symptoms as acute spasm of the esophagus; in the chronic form permanent changes are produced in the esophagus in the form of sacculated or fusiform dilatations above the seat of spasm. The dilatation is partly abdominal and partly thoracic. The abdominal portion is from 2 to 3 cm. in length, the greater portion of the dilatation being thoracic. The muscle is usually from four to six times as thick as the normal; in other cases it is quite flaccid and attenuated. The mucous membrane is usually greatly thickened and presents, in addition to the catarrhal changes, ulceration, scars, and papillary excrescences.

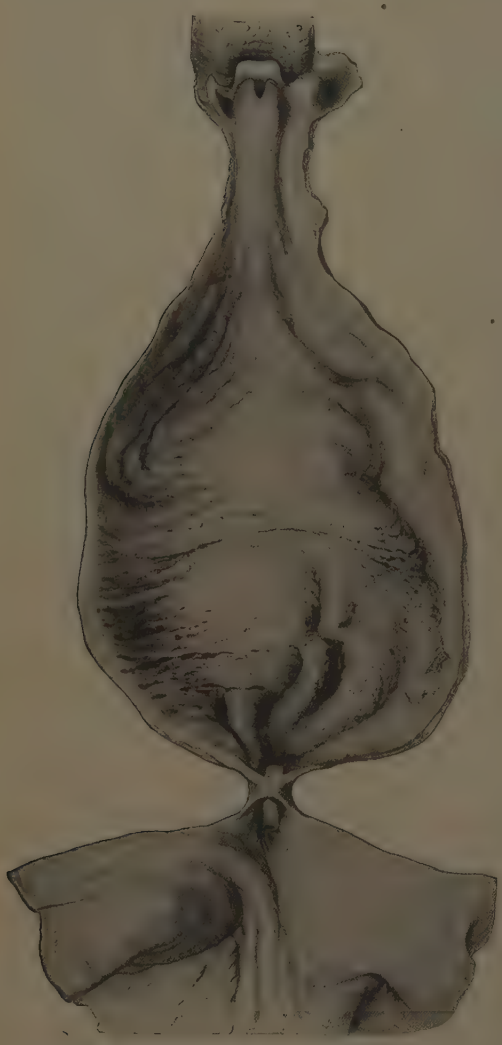


FIG. 413.—ANATOMIC PREPARATION FROM A CASE OF CARDIOSPASM WITH SACCULAR DILATATION OF THE ESOPHAGUS.

A drainage-tube is seen in the cardiac segment.

The **etiology** is obscure. The disease is spoken of under a great variety of names — fusiform, uniform diffuse, idiopathic, and spontaneous dilatation of the esophagus. It was formerly considered very rare; 120 cases have so far been reported and I myself have seen 25 more. Six different causes are given: 1, Kinking of the esophagus at the hiatus esophagi; 2, esophagitis; 3, congenital anlage, especially the forestomach; 4, atony; 5, cardiospasm; 6, degeneration of those fibers of the pneumogastric which inhibit the cardia and simultaneous uniform relaxation of the entire musculature of the esophagus. Of all the causes suggested, primary cardiospasm (von Mikulicz) seems to have most in its favor. Degeneration of the pneumogastric nerves has been demonstrated by Kraus, and his explanation is quite well-founded, nor does it conflict with von Mikulicz's view. The malady may persist

for years or decades and often dates back to the age of puberty or even to a still earlier period. As a rule the patients are thought to be suffering from disease of the stomach; they complain of pressure and fulness after eating, which disappears after vomiting. The latter act is always effected without any effort, and the vomited material often half a liter and more, is mixed with much mucus and consists of undigested food containing neither hydrochloric acid, nor pepsin, nor rennet. Sometimes the patients complain of a severe feeling of pressure, dyspnea, and hoarseness. If the patient swallows fluid after vomiting, he often feels the food passing into the stomach. On examination with a soft stomach-tube, the passage of the sound is usually followed, after a short interval, by regurgitation of the material through and alongside the tube, which gives the same reaction as the vomitus. A liter and more may be introduced into the dilatation without producing any retching. At the cardia the stomach-tube meets with more or less resistance, which is overcome by moderate pressure. Sometimes, however, the tube cannot be passed. Within the esophagus the tube is abnormally movable. When a hard sound is introduced, the cardia can be passed more readily, although a slight resistance is frequently felt. The methods of examination proposed by Rumpel, Kelling, and Einhorn, as well as others, may also be employed.

Auscultation and percussion are usually negative, and transillumination with the Roentgen rays is generally useless; on the other hand, after the ingestion of potato and bismuth porridge, radiography shows a shadow over the vertebral column corresponding in shape to that of the dilatation.

The condition is also accurately shown in the esophagoscopic picture. In addition to the saccular dilatation, a firm occlusion—either funnel-shaped, or like a rosette—is seen at the cardia. The obstruction offers great resistance or cannot be overcome at all, and excludes other changes such as fissures and ulcerations at the cardia. Quite recently von Mikulicz's method of examination, by determining the blood pressure, has been added to our resources. By this method it is found that the pressure in spasm is quite different from the normal pressure and from that which is observed in other forms of stenosis; but it is not possible by this method to distinguish secondary cardiospasm, due to carcinoma below the spasm, from the idiopathic form. The disease lasts many years, and its course is marked by long periods of remission; subjective recovery may even take place. Death may occur from profound inanition. The disease also predisposes to cancer.

Treatment.—Symptomatic; dietetic; coffee and alcohol must be avoided; daily lavage and irrigation with astringents; olive oil; anesthetics, cocain, bromids, strychnin; galvanization; gavage, continued for weeks; passage of solid sounds of large caliber at long intervals. During acute exacerbations, rectal feeding for several days. Gastrostomy has been performed in many cases as a palliative operation, but in several instances inanition had progressed too far to be arrested.

Treatment directed against the cause is based on the assumption

that cardiospasm is the primary disease, which is accordingly attacked directly by our therapeutic measures. Mild dilatation with sounds and the introduction of permanent cannulas, after the method of continuous dilatation, have not been successful. Forced dilatation with the sound through the mouth (Schreiber's rubber bulb sound) can be employed only when sounds readily pass into the stomach. In recent times von Mikulicz achieved a number of permanent cures by means of dilatation through the stomach. After opening the stomach he introduced a dressing forceps, the jaws of which were covered with rubber, and dilated the cardia to 7 cm., controlling the separation of the forceps with the other hand. Six cases subjected to this operation ended in recovery. Quite recently other operators have also reported recoveries. The method of forced dilatation through the mouth, by drawing a hollow rubber ball through the cardia (Henle), is not without danger, owing to the invagination of the cardia into the esophagus, which may cause tearing of adhesions existing between the stomach and neighboring organs. I have now adopted Geissler's method of reinforcing the rubber bulb with inserted silk netting, and effect dilatation by simply inflating the bulb. In 3 cases a complete cure was effected. Resection as suggested by Rumpel and Jaffe, is not to be recommended. Extramucous cardiography, like von Mikulicz's similar extramucous plastic operation on the pylorus, has been recommended by Gottstein, but has not so far been performed on a living subject.

Secondary cardiospasm is very frequent, especially in tumors of the cardiac portion of the stomach. It may effectually prevent the entrance of the esophagoscope into the stomach. Cases of this kind are erroneously diagnosed as cardiospasm, when the cause is a deeply situated tumor. The possibility of such a tumor should always be borne in mind when, instead of a diffuse, there is only a slight, dilatation of short extent above the seat of spasm.

STRICTURES OF THE ESOPHAGUS.

Stenoses are the most frequent diseases of the esophagus. We distinguish congenital stenosis, occlusion (obturation) stenosis (see foreign body), spastic stenosis (see motor disturbances), cicatricial stenosis, stenosis due to a neoplasm, and stenosis produced by compression from without.

Congenital stenosis is very rare and is almost exclusively confined to the highest portion of the esophagus, where it is found in association with a diverticulum above the point of constriction. A stenosis in the deep portion of the tube has rarely been observed. I myself saw a girl two and a half years old with a congenital stenosis at the level of the bifurcation.

Symptoms.—Inability to swallow any but liquid or semiliquid substances. The symptoms of stenosis are sometimes delayed for several years, and do not appear until the diverticulum above the stenosis is developed. Sounds can usually be passed, and a good deal can be done

by judicious dilatation. Operation by means of external esophagotomy may also bring about complete recovery.

Cicatricial Stenoses. These are produced by mechanical, chemical, or thermic causes, or they may follow other processes, especially the infectious diseases. They are quite frequent after the swallowing of chemical substances. If the effect on the mucous membrane is merely superficial, cicatrization does not occur; but scar formation in the submucosa leads to strictures of a valvular, fold-like, or sacculated character, or sometimes in the form of semicircular, or rarely, annular membranous constrictions. When the action has been more severe, the alterations are correspondingly more extensive. The entire circumference is involved and a tense, callous, annular stricture results. We also distinguish between single and multiple strictures. The seats of predilection coincide with the physiologic constrictions of the esophagus. One of the most common is the cardia, probably on account of its peculiar mechanism for deglutition. The part immediately above a cicatricial stricture gradually undergoes dilatation and a diverticulum is formed. Sometimes the stricture appears within the dilatation as a sharply defined ring covered with granulations, which readily bleed; sometimes an inflammation, or even ulceration and suppuration develop; and the condition may go on to perforation, either spontaneous or as the result of passing a sound. When a foreign body becomes lodged in the stricture, extraction may be exceedingly difficult, even with the aid of the esophagoscope. When the peri-esophageal tissue is involved, distortion and kinking of the esophagus result, producing an eccentric position and spiral change of axis in the tube. When this condition is present, the introduction of the sound sometimes results in the formation of false passages, particularly in the upper thoracic portion along the left wall, corresponding to the crossing of the first bronchus, and in the lower portion along the right wall, above and below the diaphragm, where the esophagus makes a bend to the left.

Symptoms.—The most prominent symptoms are dysphagia, which corresponds to the degree of stenosis and develops much more rapidly than in the case of tumors. The symptoms appear suddenly only when there is complete obstruction. The manner in which the patient eats is characteristic; even small quantities descend very slowly, and the patient attempts to facilitate their passage to the stomach by rotating and bending the head. Sometimes there are symptoms suggesting a diverticulum. Frequently large quantities of mucus and saliva are regurgitated. The symptoms of venous congestion are moderate.

The **diagnosis** in most cases is made from the history. By means of a sound the extent and shape of the stenosis is determined; if there are several, those situated lower down are often not recognized until after the first has been dilated. As large a sound as possible should be used, as small sounds are apt to catch in pockets, valves, and folds of the mucous membrane. After a few attempts the operator learns to find the entrance to the stenosis. The presence of dilatation above a stricture is recognized by lightly rotating the sound and by noting the extent

of its excursions above the stenosis. From the diagnostic standpoint esophagoscopy gives interesting pictures in cicatricial strictures, but it is of little use in the treatment. The entrance to the stricture and the dilatation can be determined by esophagoscopy, but not the position of the stricture in the deeper portions of the tube. In cases of recent stricture linear, or irregularly granulating, reddened areas, which readily bleed on contact, are seen; in old cases, longitudinal, white, patchy scars which contrast sharply with the pink of the mucous membrane; in annular or cylindric strictures the picture is that of a cicatricial funnel, with a circular or oval, central or eccentric lumen at the apex looking like a portiovaginalis (Plate VIII, Figs. 1 and 2). The respiratory movements are abolished. On approximating the tube ridge-like elevations are seen to enter the eccentric lumen, contrasting sharply with the surrounding tissue by their intensely white color (Plate VIII, Figs. 3 and 4).

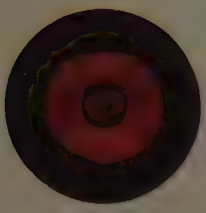
Transillumination with the Roentgen rays and radiography quite frequently give no result.

In regard to the **differential diagnosis,** it must be borne in mind that syphilitic strictures are practically confined to the upper portions of the esophagus and that they are quite large in extent. Other signs of lues are usually present also. The question of a diphtheritic or typhoid stricture is settled by the history. Strictures following caseation of bronchial glands are located in the region of the bifurcation and are very rare. Strictures caused by a peptic ulcer are situated in the lowest portion of the tube near the cardia.

Prognosis.—Strictures produced by a corrosive poison are more difficult to treat than other varieties. Even if dilatation is successful, it is almost always impossible to attain a normal degree of distensibility. Relapse occurs in almost every case. In children the prognosis is, on the whole, somewhat more favorable, because the cicatricial changes are apt to diminish, rather than to increase as the children grow. The direct mortality is very large; only the mild cases survive. The prognosis is worst in strictures involving the entire circumference of the tube and in very extensive multiple strictures. Death results from inanition, perforation, obstructing foreign bodies, or rapidly developing pulmonary tuberculosis. The patients may also die from the results of treatment. The passing of a sound or forced dilatation is not infrequently followed by perforation; even superficial abrasions or ulcerations may often suffice to produce perforation, suppuration, etc. Perforation is followed by pleurisy, mediastinitis, pulmonary gangrene, etc.

The **treatment** consists in bloodless and operative dilatation. For treatment with sounds and forced dilatation, see the general portion. If the stricture cannot be entered by the ordinary method, the introduction of sounds and dilatation with laminaria tents in the esophagoscope are resorted to. In this condition also the introduction of a large number of filiform bougies, as in the case of a urethral stricture, proves more successful than esophagoscopy. When the stricture cannot be passed, and there is great emaciation, temporary gastrostomy is

PLATE VIII.



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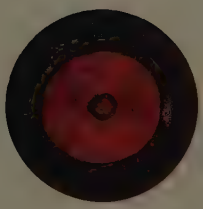

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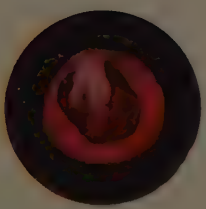

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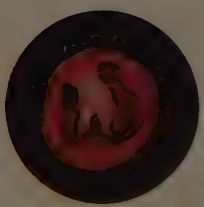

4

CICATRICIAL STRICTURE AS SEEN WITH THE ESOPHAGOSCOPE. CASE OF HYDROCHLORIC ACID BURN IN A MAN THIRTY YEARS OF AGE.

Fig. 1.—The tube is 6 cm. from the point of greatest constriction. The gullet is contracted and funnel-shaped; the walls appear moderately steep and of a deep red color.

Fig. 2.—Tube at a distance of 3 cm. The walls of the funnel appear abrupt, smooth, and of a deep red color.

Fig. 3.—Tube at a distance of 1 cm. The lumen is eccentric. At about the center of the picture, and proceeding from the wall of the gullet, there appears a whitish elevation on a dark red background.

Fig. 4.—Tube quite near the stricture. The same picture as in Fig. 3, but more distinct.

indicated. After the esophagus has been placed at rest for a time, the stricture can usually be entered; if not, continuous dilatation after von Hacker's method, modified by Socin and von Mikulicz, is employed. The patient is made to swallow a silk suture to which are attached several steel balls as large as the head of a pin, at distances of 3 to 4 cm. from each other. The silk suture is drawn through the nose by means of a Bellocq cannula and secured on the outside of the face. The steel

FIG. 414.—HENLE'S ELECTROMAGNET.
For taking up the steel balls used in von Hacker's method of dilatation of the esophagus.

balls are sometimes found in the stomach on the same day; sometimes much later. For this purpose we employ Henley's electromagnet (Fig. 414) or an alligator forceps; or the stomach is filled with water, and the water allowed to run out rapidly, bringing the suture out with it; or the suture may be found with the cystoscope. When the suture has been found, drains of successively larger caliber are introduced with the aid of the silk suture, either through the mouth or by way of the stomach,

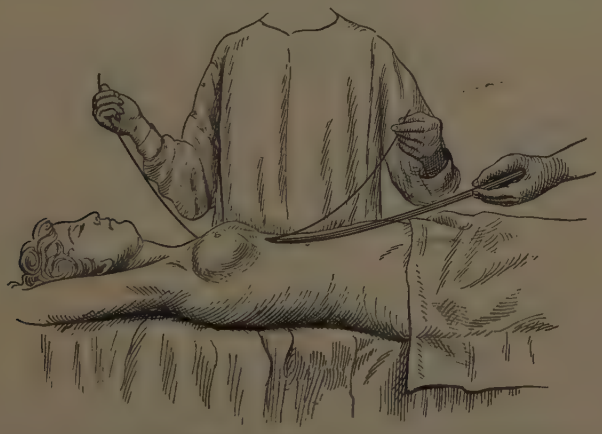

FIG. 415.—ABBE'S METHOD OF CUTTING ESOPHAGEAL STRICTURES.

and allowed to remain several days in the stricture. A drainage-tube of a certain size should remain in place from one to two weeks before the next size is introduced; in this way the occurrence of fever may practically always be avoided. When the stricture has been dilated up to 10 mm., sound treatment should be begun with two daily sessions and kept up for many months. Eiselsberg uses the conical rubber tube; many authors still recommend Abbe's procedure (Figs. 415 and 416). The stomach is opened and a string is passed through the stricture with a suitable instrument, or by swallowing a shot on a silk string. One end

of the string is brought out through the opening in the stomach and the other through the mouth or through a second external incision above the level of the stricture. The stricture is made tense by a conical bougie and is then divided by rapidly drawing the string up and down with a sawing movement. The string is withdrawn and the external wound or wounds closed. Recurrence is prevented by the frequent introduction of esophageal bougies.

Oc sner has devised a very ingenious method of dilating such a stricture as follows: A loop of silk is drawn out of the stomach as in gastric incision (Abbe's operation). Into this loop a small soft-rubber drainage-tube, three feet or more in length, is caught in the middle by traction on the ends of the doubled thread through the mouth; this loop of rubber tube is drawn through the stomach and made to engage in the stricture. "The greater the amount of traction, the smaller the stretched rubber tube, until it is sufficiently reduced in size to enter the stenosed portion; by alternating the direction of the pull the tube is drawn out by its free ends and in by the silk loop." Mention may also be made of dilatation by electrolysis, internal esophagotomy, resection

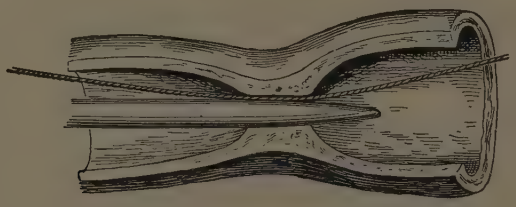

FIG. 416.—THE BOUGIE ENGAGED IN THE STRICTURE WHILE THE STRING-SAW IS BEING USED.

in the cervical, and in the thoracic portion by means of a thoracic mediastinotomy, and particularly esophago-gastro-anastomosis in Sauerbruch's chamber.

As an auxiliary to the treatment by dilatation thiosinnamin may be exhibited; by itself the drug is of no value.

Stenosis Produced by Neoplasms.—Benign growths of the esophagus are very rare, and are interesting only from a pathologic standpoint. The commonest are glandular retention cysts. They are about as large as a hazelnut, produce no symptoms, and are only found at autopsies. Dysphagia occurs only with ciliated epithelial cysts situated at the bifurcation, which result from developmental disturbances. Papilloma, fibroma, lipoma, and myoma are the tumors that occur; the latter are divided into leiomyomata and rhabdomyomata, which are usually malignant. The polypoid fibroma and myo-fibro-lipoma are usually of practical importance. The pedicle of these polypoid tumors is usually attached to the anterior wall behind the cricoid cartilage; rarely at the level of the bifurcation or at the cardia. Polyps may produce very marked symptoms, with typical signs of stenosis. The patients complain of a feeling as of a foreign body and have attacks of choking and cramps; sometimes also of dyspnea. Sometimes the polyp is forced up

into the mouth during the act of vomiting, and bitten off by the patient. In cases of benign tumors the diagnosis can be confirmed only by excising a section for examination, or with the esophagoscope. In 1 case Mackenzie succeeded in removing a polyp in the esophagoscope.

Treatment.—If possible, operation should be tried. In this condition there is much room for improvement in esophagoscopic technic. When the polyp has a long pedicle attempts may be made to bring it into the mouth by inducing vomiting with apomorphine, when the polyp may be seized with forceps and removed with a ligature, with a galvanic cautery, or with a cold snare. External esophagotomy and extirpation of the tumor and pedicle—sometimes in the esophagoscope, if the tumor is deeply situated—may also be considered. If there is rapid emaciation, gastrostomy; if asphyxia threatens tracheotomy is indicated. Spontaneous expulsion of a fibroma has been observed.

Malignant Tumors.—Sarcoma is very rare. It occurs in old people, particularly at the entrance and at the bifurcation; it does not always cause dysphagia, and sometimes metastases have already developed by the time esophageal symptoms make their appearance. During life the diagnosis can be made only with the aid of the esophagoscope and the excision of sections for examination. But 1 case of primary lymphosarcoma has been observed; secondary cases are reported by Schlagenhauffer.

Carcinoma is the most frequent disease of the esophagus (80 per cent.); it is more common in males, and in advanced age, above 50 (70 per cent.); but has also been observed in young individuals (19 years). Chemical, thermic, and mechanical irritation, especially tobacco and alcohol, appear to be etiologic factors. Leucoplakia has been frequently observed in association with carcinoma, and the disease is not rarely accompanied by pulmonary tuberculosis. Carcinoma has been seen to develop in tuberculous ulcerations, in cicatricial strictures, diverticula, on the basis of chronic catarrh, and in cardiospasm with sacculated dilatation. In the majority of cases the cancer is situated between the hilus and the cardia (68 per cent.); 12 per cent. are in the cervical portion; 6 per cent. in the suprabifurcal, thoracic segment; 14 per cent. between the bifurcation and the hilus of the lungs.

Carcinoma may be primary or secondary. Metastatic tumors are not seen in the esophagus; but carcinoma of neighboring organs may spread to the esophagus and be inoculated from a cancer situated higher up or lower down, and the entire tube may become covered with carcinomatous nodules. Two independent carcinomata, situated side by side, have also been observed. The cancer is usually an epithelioma (pavement epithelium); glandular cancer and the colloid form are more rare. As a rule only a portion of the esophagus is attacked, with the production of insular infiltration forming a segment on one side of the tube, or annular, cauliflower-like and papillomatous tumors. A dilatation develops above the cancer, particularly when it is deep seated. The growth is apt to proliferate into the air-passages, the aorta, and the pericardium.

DESCRIPTION OF PLATE IX.

Carcinoma as seen in the esophagoscope. The illustrations are not reproduced as they are seen in the lateral position; the left, right, upper, and lower portion of the picture correspond respectively to the left, right, anterior, and posterior walls of the gullet.

Fig. 1.—Carcinoma at a depth of 34 cm. The tumor obstructs the lumen on the left side. A yellowish ulcer covered with a lardaceous exudate, which bleeds readily when touched, occupies the apex of the tumor. The lumen is almost crescentic; the mucous membrane covering the opposite wall is livid and ulcerated.

Figs. 2 and 3.—Same case as shown in Fig. 1, two months later. Seen from two different points. Fig. 2 with the tube 1 cm. from the tumor. Hemispheric tumor encroaching on the lumen from the left without obstructing it completely. An ulcer occupies the apex of the tumor.

Fig. 3.—Tube directly on the tumor. The tube has pushed the tumor to the left, bringing into view the right wall of the esophagus, covered with a yellowish green, greasy exudate. The ulcerated surface bleeds profusely when touched with a cotton swab.

Fig. 4.—Carcinoma at a depth of 26 cm. Circular ulcerated tumor, showing near the lumen irregular, whitish elevations and ulcerations. Funnel-shaped depression. The picture of a broken drumhead (von Hacker), combined with a funnel-shaped stricture.

Fig. 5.—Carcinoma at a depth of 37 cm. The tumor is growing in toward the lumen from the left, the polypoid apex obstructing the lumen. Below the tumor the wall of the esophagus, in its entire circumference, appears infiltrated and ulcerated.

Fig. 6.—Carcinoma of the cardiac portion of the stomach at a depth of 42 cm. When pressure is made on the cardia, a tumor is seen projecting into the lumen from both sides; when the pressure is increased, two small, wart-like elevations appear in the anterior portion of the tumor.

Figs. 7 to 9.—Carcinoma of the cardiac portion of the stomach at a depth of 43.5 cm. Seen from three different points. Fig. 7. When pressure is made on the cardia the folds of the mucous membrane appear drawn out lengthwise, but otherwise normal. Fig. 8. On increasing the pressure a polypoid tumor covered with whitish mucous membrane enters the lumen during inspiration. Fig. 9. On increasing the pressure still more the picture presents the same appearance as the glans penis when the prepuce is drawn back. During inspiration and expiration an ulcer becomes more prominent in the upper and in the lower border of the tumor.

Figs. 10 and 11.—Doubtful case of compression tumor, gumma, or beginning carcinoma, at a depth of 20 cm. Hemispheric tumor protruding into the lumen from the left in front, displacing it to the right and backward. The lumen is in the shape of a cleft, almost crescentic. The mucous membrane is tense and paler than normal. The opposed portion of the mucous membrane is rather more livid. Fig. 10. Tube 1 cm. from the stricture. Fig. 11. Tube held close to the tumor.

Fig. 12.—Carcinoma at a depth of 38 cm., tube 5 cm. from tumor. The tumor encroaches on the lumen from the left and behind. The esophageal wall around and above the tumor is dark red. The mucous membrane shows transverse wrinkles. The surface of the tumor is paler than the surrounding mucous membranes. In appearance the tumor resembles a cauliflower.

Fig. 13.—Carcinoma at a depth of 32 cm. Tube about 3 cm. from the tumor. Tube projects into the lumen from the right and behind without obstructing it completely. The tumor is nodular. Folds of mucous membrane from the parts above the tumor extend down over the surface of the tumor.

Fig. 14.—Carcinoma of the cardiac portion of the stomach at a depth of 46 cm. The tumor appears in the left posterior portion of the picture and is covered with tense, glistening mucous membrane. The mucous membrane surrounding the tumor is velvety. The surface of the tumor is anemic and almost white in color, while the surrounding gastric mucous membrane is dark red. Small hemorrhages are seen at the apex of the tumor.

Fig. 15.—Carcinoma at a depth of 24 cm. (the diagnosis was confirmed by autopsy; the esophagoscopic diagnosis was mediastinal tumor). Hemispheric tumor protruding into the lumen from the right and behind and obstructing it completely during inspiration. The surface of the tumor is irregular on the edge which presents toward the lumen. The mucous membrane covering the tumor is slightly livid. An erosion about the size of a pea is seen near the lumen. The mucous membrane covering the remainder of the circumference is darker than normal.

PLATE IX.

the lumen (Plate IX, Fig. 5); or a picture like that of a broken drum-head may be produced (Plate IX, Fig. 4); or a funnel-shaped stenosis, or merely a circular ulcer, may be seen. At the cardia we usually see the rosette-form, rigid and wax-like, and immovable during respiration. Plate IX, Figs. 12 and 13, show cauliflower-like tumors, which are very common; papillomatous forms also are not rare. Sometimes tumors in the cardiac portion of the stomach can be seen through the esophagoscope. In such cases the cardia presents a normal, rosette-like picture, opening and closing with each inspiration and expiration. After the cardia has been passed the livid but much paler tumor is seen within the dark red, velvety mucous membrane of the stomach (Plate IX, Fig. 14). Sometimes when the cardia is opened instead of the normal invagination of the gastric mucous membrane a plug of tumor enters the tube and occludes the lumen (Plate IX, Figs. 6, 7, 8, and 9); sometimes individual folds of the cardia are made to bulge by tumors situated beneath them.

The *prognosis* is absolutely unfavorable. Death occurs from inanition, cachexia, or from complications. Death occurs most quickly from perforation into large vessels. Perforation into the trachea, into the left bronchus, and into the pleura is quite frequent. Carcinoma of the esophagus shows less tendency to produce metastases than carcinoma of most other organs. Metastases in the skin are rare. The average expectation of life is from one to two years, rarely longer. von Hacker observed a patient in whom the diagnosis had been confirmed by esophagoscopy and who lived four years.

Treatment.—Opiates, cocain, lavage of the esophagus with Boas' recurrent silk catheter, using warm water or a solution of salt, borax, soda, or lime-water; irrigation with a 1 to 4 per cent. silver nitrate solution, 1 to 2 gm.; or 8 to 10 drops of a 1 per cent. silver nitrate solution daily. Atropin to diminish the secretion of mucus; potassium iodid, 1.5 to 2 gm.= 20 to 30 gr.; and to dilute the saliva, 1.5 to 2 gm. =20 to 30 gr. of potassium iodid, or 10 per cent. sodium bicarbonate. Ulcerations should be disinfected with iodoform, airol, or bismuth.

The diet should be almost exclusively semiliquid and liquid; meat finely scraped only, rolls and bread without crust, jellies, hash. Milk coagulates and is not well borne; carbonated beverages are not suitable. The various nutrient preparations are useful. To assist gastric digestion, hydrochloric acid is prescribed.

Treatment with Sounds.—Some surgeons decline to use sounds and insist on the performance of gastrostomy. According to my own experience gastrostomy prolongs life only in a very few cases and is more apt to hasten death by pneumonia and other postoperative complications, even if local anesthesia is employed. On the other hand, the danger of perforation, if the sounds are carefully handled, is very slight. Cylindric or conic bougies (see Fig. 387) are the best. Dilatation, after von Hacker, by means of distended drainage-tubes (Fig. 402), which are not left in place longer than a few hours and are introduced several days in succession, is much better and much less dangerous than

the introduction of a permanent cannula. Particles of tissue occluding the lumen can be removed with forceps in the esophagus, and this often gives so much relief that the patients themselves ask to have it done. The operative treatment of carcinoma is discussed under Operative Methods. I shall merely mention in this connection that if the patient emaciates rapidly and the introduction of sounds proves unsuccessful, a gastric fistula should be made. Among the radical operations that have been tried are resection of the esophagus in the cervical and in the thoracic portion by a posterior thoracic mediastinotomy, and by anterior thoracotomy in Sauerbruch's chamber.

Compression stenoses may be produced by many different organs. They are most frequent in the highest portion of the esophagus from enlargement of the thyroid gland, of lymph-glands, aortic aneurysm, mediastinal tumors, bends in the vertebral column,[9] thickening and ossification of the plate of the cricoid cartilage, and vertebral ecchondroses.[45] The symptoms are practically the same as those of carcinoma and gumma. Sounding is of no use whatever; the sound encounters an obstacle, which is overcome by a certain amount of pressure, like climbing over a mountain. Sometimes the diagnosis can be confirmed by esophagoscopy, although even with this method the examiner runs the risk of making mistakes.[12] When the mucous membrane is movable over a tumor which completely occludes the lumen, the chances are in favor of compression stenosis. The diagnosis becomes probable if on resorting to other methods of examination we discover dulness over the sternum, symptoms of aneurysm, or a hard palpable tumor of the thyroid gland. Transillumination with the Roentgen rays and radiography are particularly useful, but even these methods do not altogether guard against errors. A violently pulsating tumor,[12] which in the Roentgen-ray picture was taken for an aneurysm, turned out at the autopsy to be a primary carcinoma of the esophagus adherent to the aorta. The treatment is merely symptomatic unless the primary disease can be removed.

DILATATIONS OF THE ESOPHAGUS.

We distinguish dilatation involving the entire circumference of the esophagus and diverticula or bulging of a small portion of the circumference of the tube.

Dilatations are subdivided into *total*, usually produced by spastic conditions at the lower end of the esophagus (see Cardiospasm) or atony of the muscle, and *partial* dilatation, involving only a segment of the tube. The latter are either congenital or secondary and situated above a stricture. Congenital dilatations are usually in the abdominal portion of the esophagus or in the lowest portion of the thoracic segment, extending as far as the hiatus (fore-stomach). Congenital dilatations also occur in the suprabifurcal thoracic segment. Partial dilatations situated above a stricture are quite frequent; the deeper the seat of the stricture and the longer its duration, the larger will be the dilatation.

Diverticula of the Esophagus.—On etiologic grounds we distin-

guish traction and pulsion or pressure diverticula. In *traction diverticula* the wall is distorted by a pull acting from without. These diverticula are small, situated usually on the anterior wall, and produce few or no symptoms during life. They result from softening and suppuration of tuberculous lymph-glands, especially, at the point where the esophagus crosses the left bronchus (80 per cent.); from distortion of the esophagus due to disease of the pleura, the lung, or the pericardium[46]; from perichondritis and necrosis of the cricoid cartilage[9]; and from adhesions with the thyroid gland when the latter is the seat of cystic degeneration. Traction diverticula of the posterior wall of the esophagus have been observed after mediastinitis and caries of the vertebræ. Foreign bodies are very apt to lodge in the diverticula[47] and may lead to ulceration and perforation. Sometimes several traction diverticula are found in the same esophagus. In rare cases the small end of the funnel may be directed downward, and in such a case the entrance of food may produce a traction-pulsion diverticulum. As a rule traction diverticula produce no symptoms because the apex of the diverticulum is at a higher level than the opening, so that the food which enters the esophagus does not stay in the diverticulum. Traction diverticula favor the development of carcinoma.

Pressure diverticula are produced by pressure. The mouth of the diverticulum is at a higher level than the sacculation. Pharyngo-esophageal or Zenker's pulsation-diverticula are situated in the posterior wall of the esophagus at the junction of the latter with the pharynx. About 100 cases have been reported. Their production is favored by the physiologic narrowing at the level of the constrictor of the pharynx and the hiatus which exists at that point in the longitudinal muscular layer. As a rule they are small, but may become very large and extend into the thoracic cavity.[48] They are usually situated on the posterior wall and bulge to the left and forward, sometimes to both sides. Pediculated and sacculated diverticula are described.

Symptoms.—At the beginning of the disease the patient complains of dryness and a scratchy feeling in the throat, frequent hawking, marked nausea, expectoration of mucus, and a flow of saliva. Hawking brings up small particles of food from the last meal mixed with mucus. Sometimes there is a feeling of pressure when solid food is taken. After some years a feeling as of a foreign body in the throat develops; symptoms of stricture and dysphagia make their appearance, and small quantities of undigested food are regurgitated with retching *during a meal*, in contradistinction to what occurs in cases of diffuse dilatation, when large quantities of food are ejected "with a rush" *after eating*. Very full and distended diverticula sometimes produce dyspnea and hoarseness from the pressure of the contents. Congestion due to compression of neighboring blood-vessels is also observed. Decomposition sometimes takes place in the diverticulum and gives rise to great fetor of the breath.

The **diagnosis** may often be made by the history alone, which is very characteristic—long duration of the symptoms and regurgitation

of small quantities of undigested food. We may also examine with a sound and thus discover at a depth of 20 to 25 cm. an obstacle which may sometimes be passed during the act of swallowing or coughing, permitting the sound to enter the deeper portions of the esophagus. This, however, will occur only if the end of the sound is above the entrance to the diverticulum and has not been introduced as far as its floor. The results of sounding are frequently quite variable.[49] Examination with the *x*-rays, after eating potato and bismuth porridge, shows at the level of the second thoracic vertebra a round or oblong shadow, from the size of a cherry to that of an apple and sometimes as large as a child's head (Fig. 417). In the esophagoscopic picture the diverticulum appears as

FIG. 417.—SKIAGRAPH OF AN ESOPHAGEAL DIVERTICULUM. (Courtesy of Dr. N. B. Oliphant; case of Prof. Kocher.)
The sac was filled with potato and bismuth porridge.

a wrinkled sac of mucous membrane; the mucous membrane forms a kind of sill,[50] which is quite characteristic, over which the tube glides into the esophagus during deglutition. The position and size of the diverticulum can frequently be determined with the esophagoscope.

Although the condition is benign, the **prognosis** is not good. Of 66 patients who were not operated upon, 36 died of their malady. The life of these patients during their last years is unbearable. Death occurs from inanition or the aspiration of regurgitated food (abscess of the lung); ulceration of the diverticulum may lead to phlegmonous inflammation, perforation, empyema, or pulmonary gangrene. Carcinoma has also been observed within a diverticulum.

Treatment.—Improvement can be secured by the sound treatment, but recovery is hardly to be expected (only 1 case is known). Gastrostomy is recommended as a palliative operation, but most of the patients operated upon have died of pneumonia. As a preliminary operation to extirpation of the diverticulum, gastrostomy is advisable. Extirpation, which was first performed by von Bergmann in 1890, has since been carried out in 44 cases, with a mortality of 7, or 16 per cent.; but the 7 cases all occurred during the early history of the operation. Quite recently Lotheissen [51] has recommended dilatation of the esophagus at the seat of the diverticulum with an inflatable rubber bulb. No other cases have as yet been reported. By the employment of certain symptomatic measures, such as suitable diet, position (the patient should lie on the sound side while eating), irrigation of the diverticulum, the use of sounds, etc., the disease may be held in check for years.

Pressure diverticula of the esophagus are much more rare. The congenital form may occur at any point of the anterior periphery; it is usually situated at the level of the bifurcation. In many cases they appear to develop from a traction diverticulum with the apex directed downward (traction-pressure diverticulum). Pressure diverticula in the lowest portion of the esophagus have been described by various authors [52]; as yet we have no autopsy findings from cases of this kind. In my opinion we have to deal with a right-sided sacculation of a diffusely dilated esophagus immediately above the diaphragm, accompanying cardiospasm. The only absolutely certain pulsion diverticula above the cardia so far observed were discovered incidentally at the autopsy and produced no symptoms during life. The only suggestion that has been made for the treatment is gastrostomy as a palliative operation.

OPERATIVE METHODS.

Electrolysis is used with variable success in cicatricial and carcinomatous strictures. It has been employed through the mouth,[53] through an esophageal fistula, through a gastric fistula, and by a combination of these methods. The negative pole, which is applied to or introduced into the stricture, consists of a knob-shaped or conic metal sound, screwed to the lower end of the flexible guiding staff; the positive pole is applied to the chest. I. A. Fort uses electrodes in the shape of knives (4 to 15 ma.; in carcinoma, up to 32 to 36 ma.), a few seconds to a quarter of an hour at a time. von Mikulicz applied the second electrode to the stricture through a gastrostomy opening.

Cauterization.—According to modern principles of treatment cauterization is applicable only in the case of fissures and fold-like or valve-like alterations. A scab is formed at the site of the cicatricial tissue, and when this separates a secondary stricture is produced. Rosenheim[7] uses a porcelain point and von Hacker[9] one in the shape of a hook.

Internal Esophagotomy.—Two different methods are employed, as in the case of urethrotomy. The stricture is divided either as the

instrument is carried in or as it is withdrawn. In the first method the blade, which is screwed to a small flexible bougie, is introduced into the stricture; with the other method, which is more conservative, the small probe-like portion of the instrument which carries the blade is first passed through the stricture, and as it is withdrawn the blade opens and cuts through the stricture. Internal esophagotomy was first performed by Maisonneuve. The operation has also been performed from the opposite direction through a gastrostomy opening. As the operator is forced to work in the dark, in an organ situated near other vital organs, the method is a dangerous one, and death has repeatedly occurred from hemorrhage. In the case of short scars projecting far out into the lumen, several small superficial, notch-like incisions are made, and this procedure appears to be free from danger. Esophagotomy must be followed by dilatation with sounds.

External or Cervical Esophagotomy.—Combined External and Internal Esophagotomy. Cervical Mediastinotomy.—External or cervical esophagotomy is employed: I. For the extraction of foreign bodies. II. In cases of cicatricial strictures. (1) Of the highest cervical portion; (*a*) for dividing a stricture from without; (*b*) for passing sounds in the opposite direction (from below upward); (*c*) for feeding the patient (given up in favor of gastrostomy). (2) At a point more than 20 cm. from the alveolar margin; (*a*) to facilitate dilatation; (*b*) as a preliminary to Gussenbauer's combined esophagotomy. III. In carcinomata situated high up; formerly employed as a fistula for administering food; as a preliminary operation to extirpation; and for introducing sounds in the opposite direction; now abandoned in favor of gastrostomy.

Operation.—The patient is placed in the dorsal position, with the cervical vertebra overextended and the head turned to the right. The incision is made at the anterior edge of the left sternocleidomastoid muscle, the sheath opened, the muscle drawn out with a blunt hook, the deep layer of the cervical fascia divided on a grooved probe, the blood-vessels and nerves displaced to one side with a blunt hook, and the thyroid gland drawn to the median line without compressing the trachea. This exposes on the floor of the wound the trachea and behind it, projecting slightly over the edge, the esophagus, and in the angle formed by the two the inferior laryngeal nerve, which must be avoided. The esophagus is recognized by the longitudinal striation of its fibers and its peculiar color. The esophagus is now drawn to the surface with silk fixation sutures, isolated from the surrounding structures with gauze pads, and opened between the sutures. When the wound is to heal by first intention the esophagus is sutured in three layers: mucous membrane, muscle, and a row of Lembert sutures in the invaginated external coat. At one point a tampon or cigarette drain is inserted and the rest of the wound is closed. Short, membranous valvular strictures in the cervical portion may be treated by dividing the stricture from without and bringing the edges of the wound together transversely to the long axis of the esophagus.[54] Strictures at the top of the thoracic portion can

be reached conveniently by means of an external esophagotomy. An esophageal tube is inserted through the mouth and an incision is made on the tube above the stricture; a grooved director is then inserted in the opening and the stricture divided on the director.

The *results* of external cervical esophagotomy in the treatment of cicatricial strictures are very unfavorable. The mortality ranges between 45 and 60 per cent. When performed for the removal of foreign bodies that are wedged fast and cannot be dislodged in the esophagoscope this operation gives good results.

Cervical esophagostomy is performed in the same way as the preceding operation, except that a temporary or permanent fistula is purposely made. For that purpose the mucous membrane is sutured to the external skin.

Combined esophagotomy (after Gussenbauer) is employed for strictures in the upper part of the thoracic segment; the stricture is brought into view by means of an external esophagotomy and divided with a knife.

Cervical Mediastinotomy.—In 2 cases of phlegmonous inflammation of the esophagus von Hacker,[55] after performing esophagotomy, succeeded in reaching the deeper tissues by going down in the retroesophageal space to the median side of the large vessels. L. Heidenhain went down between the heads of the sternocleidomastoid muscle from the clavicle on the right side, between the carotid and the jugular vein; on the left side, to the outer side of these two vessels. In all, 6 cases were subjected to operation for phlegmon, of which 2 ended fatally.

Gastrostomy and Gastrotomy.—Gastrostomy is performed when the esophagus is impermeable, in order to introduce into the body the nourishment necessary for the preservation of life. In benign conditions life may be sustained in this way indefinitely. Sometimes it is employed as a temporary measure, as in the case of cicatricial strictures, for the purpose of instituting continuous dilatation (von Hacker). The technic has been perfected to such a point that it is now a simple operation, which can be performed under local anesthesia without much discomfort to the patient. For the technic of the operation, see Operations on the Stomach.

Resection of the cervical portion of the esophagus has been performed (1) on account of impermeable cicatricial stricture. The operation is a very serious one and usually ends fatally. It is, therefore, indicated only in a disease the removal of which is absolutely necessary for the preservation of life. (2) On account of carcinoma situated high up in the esophagus. The position of the stenosis in the cervical portion furnishes the indication: the higher the stenosis, the more easily can resection be performed; also the extent of the stenosis—cancers of more than 3 cm. in extent are not suitable for the operation. The patient's strength and general condition should also be considered.

The auxiliary operations required are: (1) External esophagotomy, which has been given up altogether in favor of gastrotomy, because the wound which is produced is more unfavorable for the success of the

later resection. The operation was formerly resorted to for the purpose of confirming the diagnosis; for that purpose we now employ esophagoscopy and excision of a section for examination. (2) *Gastrostomy* is performed for the purpose of improving the patient's nutrition and because it enables one to dispense with gavage after the operation. If necessary it may also be performed for the purpose of feeding the patient through the artificial opening for the rest of his life. (3) *Tracheotomy* may become necessary if the disease has involved the pharynx. It is best performed at the end of the operation, in order to avoid the entrance of blood into the trachea and infection of the wound with tracheal mucus.

The results of resection are favorable only in cases of cicatricial stricture. Out of 4 cases of stenosis of the highest part of the cervical portion which were operated upon, 1 ended fatally. The operation has so far been performed 15 times [9] for carcinoma of the highest portion of the cervical segment; all the patients died; 5 immediately after the operation and the others from recurrence. The cases of Czerny, Garrè,[56] and von Mikulicz [57] lived the longest—about one year.

Resection is performed practically in the same way as external esophagotomy, except that the incision is extended further upward and downward and as deeply as possible into the sound tissue—if necessary, on both sides—uniting the two sutures at the jugulum. The sternal insertions of the sternocleido muscles may have to be detached.[58] The esophagus is drawn out of the wound, using the blunt dissector as much as possible, and the tumor removed by a wide incision including much of the sound tissue. If the resected piece is not larger than 4 cm., the defect is best closed with a circular suture [59]; if it is larger, the upper end of the lower segment of the esophagus is sewed in as a fistula, and later the fissure is closed with external skin by means of a plastic operation [57] (see Plastic Operations on the Esophagus). When the operation is carried into the thoracic cavity,[58] the lower extremity is ligated and dropped and the upper extremity sutured into the wound.

After-treatment.—Gastrostomy obviates the dangers of mediastinitis and pneumonia from the aspiration of food, particularly when the larynx, trachea, and recurrent nerves are preserved. The danger of secondary hemorrhage is also inconsiderable if the ligatures are carefully applied, providing mediastinitis does not develop. The retention of secretions is prevented by frequent changing of the dressings.

Dorsal Mediastinotomy, Posterior Thoracic Esophagotomy, and Resection of the Esophagus in the Thoracic Segment.—Dorsal mediastinotomy was first performed on account of caries of the vertebra, then for mediastinitis and for the removal of foreign bodies.[60] While in this operation the mediastinum only is opened, the esophagus also is incised when posterior thoracic esophagotomy is performed. The operation is, therefore, much more complicated and the lacerations of the pleura, which cannot well be avoided, are apt to lead to infection. The operation was performed by Henle[12] and Enderlen[61] for removing dental plates which had become wedged fast in the infrabifurcal portion

of the esophagus. Henle's patient died on the ninth day after the operation; Enderlen's was discharged cured, but it was nine months after the operation, owing to the occurrence of complications.

Judging from past experience, resection of the thoracic portion by means of dorsal mediastinotomy does not appear to promise much success on account of the difficulty of introducing sutures. The first experiments on animals were made by Nassiloff. After him a number of surgeons operated not only on dogs and human cadavers but also on the living subject (Rehn,[62] Llobett,[63] Tuffier,[64] Faure[65]) for carcinoma or cicatricial strictures. In most cases the surgeons were unable to complete the operation and none of the patients survived. Enderlen recommends the following procedure: A rectangular flap is made with its base along the vertebral column, from the spinous process of the third to that of the ninth thoracic vertebra, and extending to the median edge of the scapula. All the soft parts are then divided down to the ribs and the flap is turned back; the periosteum is dissected away from the ribs and pieces 10 cm. in length are resected. The pleura is carefully detached toward the vertebral column and on the ventral side, taking care to avoid the sympathetic nerve. An esophageal sound is introduced through the mouth and the esophagus is exposed, avoiding the azygos vein, the thoracic duct, the two pneumogastric nerves, and, on the ventral side, the edge of the pericardium. The surgeon is now working at a depth of from 12 to 14 cm. According to Enderlen it is possible to make a small incision in the esophagus and close it with sutures; but the introduction of circular sutures, which would be necessary for a resection, can, in his opinion, never prove successful because the unavoidable laceration of the nutrient blood-vessels as the esophagus is drawn out of the wound must cause necrosis of the resected portion.

Resection of the cardial portion of the esophagus was, so far as I know, performed only once by von Mikulicz,[12] in 1896, for carcinoma at the cardia; the patient died soon after the operation. Later Krukenberg made an attempt to solve the problem experimentally.

Evulsion of the entire esophagus was also performed but once by von Mikulicz, in 1899, for a carcinoma situated in the infrabifurcal thoracic portion. This patient also died in twenty-four hours. The left half of the thorax was opened by infraction of the seventh and ninth ribs, and the diseased portion of the esophagus dissected out with a blunt dissector and divided at the cardia. The gastric extremity was then closed with purse-string sutures and a gastrotostomy (after Witzel) performed. An esophagotomy was then done on the left side of the neck, and through the opening two heavy silk sutures were introduced with an esophageal sound, carried as far as the gastric end of the esophagus, and then secured at the upper end of the esophagus. The tube was then divided transversely above this point. After dissecting away the esophagus as far as possible into the mediastinum with the finger, the entire excised piece of the esophagus was drawn out through the abdominal wound by means of the silk sutures. The remaining upper piece of the cervical portion was then sutured

into the upper angle of the wound. The mediastinum was packed from above and below.

Extirpation of a diverticulum of the esophagus was advised by Kluge[46] in the beginning of the last century, and first performed successfully by von Bergmann in 1890.[49] Up to the present time 44 cases, with 7 deaths, have been reported. Only the upper diverticulum is suitable for the operation. A sound is first introduced into the diverticulum by way of the mouth; and if the way into the lower portion of the esophagus can be found, a second sound is introduced in order to make the operation easier. The esophagus is then exposed as in a cervical esophagotomy; the diverticulum searched for and separated from its surrounding tissues with a blunt dissector, until the part that connects it with the esophagus and which is usually pedunculated has been exposed. The wound is then isolated with pads and the sac removed with knife and scissors. Filling the diverticulum with porridge adds to the danger of infection. Pulling on the esophagus must be avoided because it obscures the direction of the canal, and may thus make it impossible to close the esophageal wound. The wound should be closed in three layers. Kocher[48] constricts the neck of the diverticulum, cauterizes the stump with a Paquelin cautery, and closes the wound with two rows of sutures; the rest of the wound is packed. If sutures cannot be introduced, a drainage-tube may be left in place for a time. It is advisable to do a primary gastrostomy two weeks before the operation.

Girard's Method of Invaginating the Diverticulum.—After the diverticulum has been exposed it is invaginated into the esophagus, and the funnel thus produced closed with three rows of sutures. Girard cured 2 cases by this method. It is applicable only to small diverticula, because larger sacs necessarily produce symptoms of stenosis. Permanent recovery probably occurs by obliteration of the sac.

Plastic operation becomes necessary when the defect caused by the resection cannot be closed or the ends of the esophagus cannot be brought together. Right-angled skin flaps are made and united directly with the gap[66] in the posterior wall or with the bridge of mucous membrane that has been left. At a second operation the pedicles of the flaps are divided to the right and to the left and united to form a tube, which is sutured to the lumen of the pharynx of the esophagus. The skin is then undermined on both sides and brought together over the artificial tube. Before von Hacker, von Mikulicz,[57] in 1877, closed a small defect with a pedunculated flap, with the skin surface turned inward. Garrè,[56] in a case in which the tumor was adherent to the larynx and trachea, extirpated the skeleton of the larynx and successfully covered the gap with the healthy laryngeal membrane.

Operations in the Sauerbruch Chamber.—Realizing the hopelessness of endothoracic methods of operation, which had been in use up to his time, von Mikulicz endeavored to devise a method of approaching the esophagus through the front of the thorax. To do this it is necessary to maintain respiration during the operation in spite of the pneu-

mothorax which may develop, and for this purpose von Mikulicz employed artificial respiration, first with bellows, and later with Kionka's anesthetizing apparatus in combination with artificial respiration. Dombromysslow[67] adopted the same method. All the experiments that I made with von Mikulicz[68] failed. Sauerbruch[69] then conceived the idea of circumventing the pneumothorax by opening the thoracic cavity *under negative pressure*. For this purpose he constructed a special chamber (Figs. 327 and 328). The method is excellent, and with its aid von Mikulicz,[68] in conjunction with Sauerbruch,[42] has taught us how to perform operations on the esophagus by the ante-thoracic route. Sauerbruch, in his work on "Chirurgie des Brustteils der Speiseröhre," described the technic of "ante-thoracic esophagotomy, esophago-gastro-anastomosis," and "resection of the esophagus." *

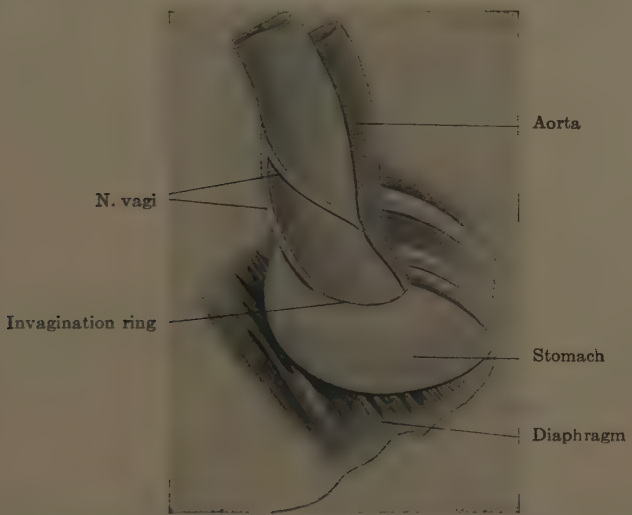

FIG. 418.—RESECTION OF STRICTURE AT CARDIAC END BY INVAGINATION, FOLLOWED BY RESECTION. Invagination of esophagus (in two sittings).

Resection.—1. In the case of small but deep-seated tumors the operation should be performed in two sittings. The principle of the operation consists in displacing part of the stomach into the pleura and invaginating the tumor into the displaced portion. At the second operation the stomach is opened through the abdomen and the invaginated pieces resected along with the tumor.

Thoracotomy in the seventh intercostal space; incision 20 cm. long. A cone of stomach from 3 to 5 cm. in length is grasped and drawn over the tumor, so that the latter disappears in the stomach. An important preliminary operation consists in carefully dissecting out both pneumogastric nerves. The stomach is united to the esoph-

* The instruments necessary for this operation must be specially constructed. They must be at least from 26 to 30 cm. long. so as to enable the surgeon to operate at a distance from his work.

agus by a circular suture from 2 to 3 cm. above the tumor, and the opening in the stomach secured, as described above, to the diaphragm (Fig. 418); the wound is then closed. After two weeks the stomach is opened through the abdomen and the invaginated portion of the

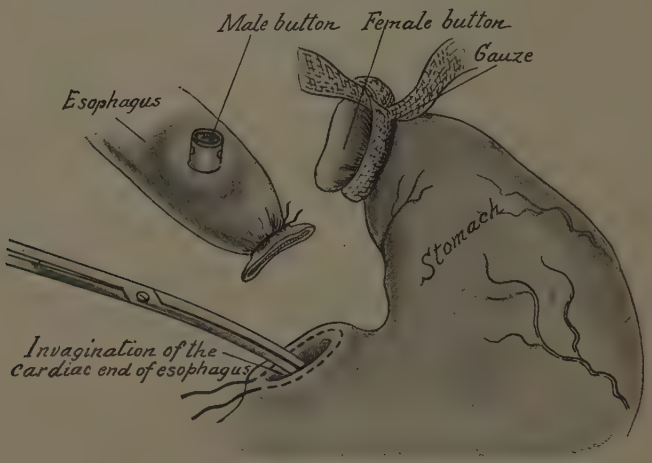

FIG. 419.—RESECTION OF A STRICTURE IN THE UPPER PORTION OF THE LOWER THORACIC SEGMENT. Invagination of the lower extremity.

esophagus resected. The wounds in the stomach and abdomen are closed at once.

2. The operation is more difficult in cases of tumors seated higher up. Resection in these cases has to be done at one sitting and is combined with esophagogastroanastomosis (Figs. 419 and 420). After closing

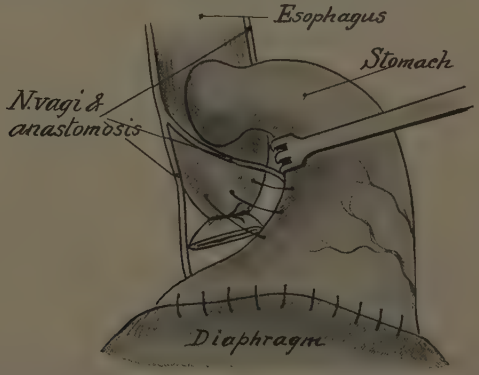

FIG. 420.—ANASTOMOSIS WITH MURPHY BUTTON AFTER RESECTION AND DROPPING THE ESOPHAGEAL STUMP INTO THE STOMACH.

the upper stump of the esophagus the lower stump is invaginated into the stomach and also closed, after which a typical esophagogastroanastomosis with a Murphy button is performed. For greater security, the upper esophageal stump may be buried in a fold of the stomach wall, so that it also may be covered with serous membrane.

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CHAPTER XLIX.

SURGERY OF THE STOMACH.

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ANATOMIC CONSIDERATIONS.

Under pathologic conditions there is no organ in the body which varies so much in size, position, and relations as the stomach, and although space does not permit of a complete anatomic description of the normal stomach, yet some consideration of its anatomy is called for in an article dealing with gastric surgery.

When relaxed (as it is usually seen when operating or at post-mortem examination) it is a somewhat pear-shaped, hollow organ situated in the left hypochondriac and epigastric regions, covered in two-thirds of its extent by the liver and diaphragm and to the extent of one-third by the anterior abdominal wall and reaching to within 2 inches of the umbilicus, but it may be so contracted in certain cases of stricture of the esophagus as to lie away from the surface, completely under cover of the liver and diaphragm, or it may be so dilated in some cases of stricture of the pylorus as to occupy every region of the abdomen and to extend into the true pelvis.

The general axis is inclined obliquely downward and to the right from the only normally fixed part, the cardiac orifice; but the axis may be almost vertical, as in some cases of gastroptosis, or horizontal, as in some cases in which the pylorus is fixed to the under surface of the liver by adhesions or by a short gastrohepatic mesentery. The cardiac orifice is situated at the back of the abdomen on the left of the tenth dorsal vertebra, which spot corresponds in front with the junction of the seventh left costal cartilage to the sternum.

The pyloric outlet is normally situated to the right of the eleventh or twelfth dorsal vertebra. When the stomach is empty the pylorus lies 2 inches below, 1½ inches to the right, and 1½ inches in front of the cardiac orifice, but when the stomach is distended the pylorus lies 2½ to 3 inches to the right and 2 inches in front of the cardia. It may, however, be firmly fixed to the under surface of the liver by adhesions, or so freely movable that when it is the seat of tumor it may be displaced into every region of the abdomen, and I have even seen it in the pelvis.

The pylorus is normally closed except when food is passing, but an examination of the pylorus in a large number of living subjects during operation has convinced me that post-mortem findings are not always safe to argue from in the living, for I have very frequently

found the pylorus patulous, readily permitting the passage of the forefinger when the stomach was empty. It may be so contracted in disease as barely to admit the passage of a probe or, rarely, it may be found so patulous as to permit two fingers to pass.

A description of the stomach would not be complete without mentioning the fact that under the influence of peristalsis the shape of the stomach is not a thin-walled, flaccid sac, corresponding to the usual description as seen in the dissecting room; for when contracting it may be seen to be composed of a cardiac division somewhat globular in shape and a pyloric portion resembling thick-walled intestine.

Cannon[1] fed cats with pulpy food impregnated with subnitrate of bismuth and then observed the movement of the stomach contents by means of the Roentgen rays. He found the fundus to be an active reservoir for the food, squeezing its contents gradually into the pyloric part, which then contracted on it by a series of peristaltic waves. Each wave took about thirty-six seconds to pass from the middle of the stomach to the pylorus, and the different waves followed each other at intervals of ten seconds. As they passed the incisura angularis the indentation in the lesser curvature became deeper. The cardiac sac did not take part in the active peristaltic wave, but seemed to squeeze its contents gradually into the pyloric part.

Hirsch and Cannon have shown that the discharge of food takes place intermittently at irregular intervals, according to the condition of the food which reaches the pyloric canal.

The **lymphatics of the stomach** are very numerous. They form a plexus of dilated lymph-sinuses in the submucous tissue and then pass toward the upper and lower margins, where they traverse a number of lymphatic glands which lie along the gastric borders of the small and great omenta respectively. Thence they pass to the celiac glands, which lie beside the aorta above the origin of the superior mesenteric artery, those of the lesser curvature following the course of the coronary vessels until the cardiac orifice is reached, when they turn down behind the pancreas to reach the celiac glands. Those on the greater curvature run with the right gastro-epiploic vessels, and in part with the splenic vessels, and reach the same lymphatic glands. Thence they pass together with the vessels which drain the mesenteric glands to open into the lower end of the thoracic duct. (For diagram of lymphatics of stomach see Fig. 483.)

The **nerves of the stomach,** derived from the terminal branches of both pneumogastrics and from sympathetic branches of the solar plexus, are very abundant, and not only account for the very severe pain caused by ulceration, but also for the severe collapse produced by injury; though it is a mistake to suppose that manipulation of the pylorus is always attended by the severe shock suggested by the experiments made by Crile; for in many cases I have freely handled the stomach and pylorus, and operated on them without the patient's experiencing more shock than would be expected after any abdominal operation. When the pylorus is adherent and the parts have to be

much dragged on severe shock is not infrequently seen, but this is due to interference with the large sympathetic nerves and ganglia behind the pylorus.

The relation of the sympathetic nerves with the seventh, eighth, and ninth spinal roots accounts for the superficial tenderness of the epigastrium in ulceration and for the reflected left shoulder-blade pain. This is well shown in pyloric adhesions complicating cholelithiasis, where, though the pain is originally on the right passing to the right infrascapular region, as soon as the pylorus becomes involved in the inflammation or tied down by adhesions, the pain passes also to the left subscapular region.

DIAGNOSIS OF GASTRIC DISEASES.

The time has passed in which the surgeon may rest content to act on a diagnosis already made for him, leaving with his medical confrères the onus in case of error; for he cannot shirk the responsibility of operative interference should such be found necessary. He must, therefore, go over the whole of the medical evidence and be prepared to supplement it by surgical methods should such be necessary to elucidate the case.

A general and a special inquiry are necessary in every case, the former involving the question of age, sex, occupation, habits, and the mental, moral, and physical conditions, together with the history of the patient and the disease; the latter including all that can be ascertained by a physical examination.

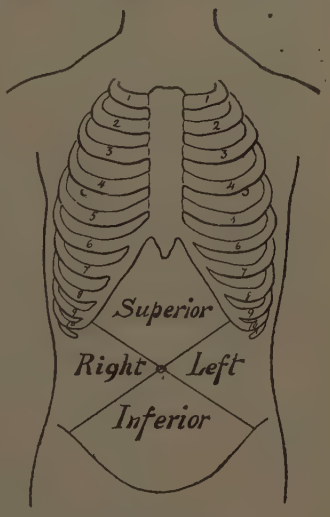

Fig. 421.

Abdominal Regions.—I have found the method of artificially dividing the abdomen into four regions by two lines passing from the ninth costal cartilage to the opposite anterior superior spine to simplify for clinical purposes the surgical anatomy of the abdomen. We can thus speak of superior, inferior, right, and left abdominal regions, as shown in the appended diagram (Fig. 421).

Inspection should always precede other diagnostic efforts. The retracted superior abdominal region significant of starvation from esophageal stricture; the rigid immobile abdominal wall of incipient peritonitis; the distention of the abdomen and the shallow breathing of general peritonitis; the sighing respirations in internal hemorrhage; the irregular, catching breathing in diaphragmatic peritonitis or pleurisy due to subphrenic inflammation; the fixed and bulging ribs in subphrenic abscess; the tumor moving with respiration, often visible in

cancer of the body or pyloric end of the stomach; the enormous bulging of the upper or even of the whole abdomen in acute gastric dilatation; the visible peristalsis from left to right in obstruction at the pylorus—are among the many important points that may be revealed by inspection.

Palpation follows inspection, and is perhaps the method which we can least afford to omit. The rigid recti of perigastritis or incipient peritonitis; the fixed right rectus of pyloric or duodenal ulcer; the fixed left rectus of ulcer at the cardiac end of the stomach; the tenderness elicited on pressure in the superior abdominal region in all inflammatory diseases and its absence in cancer; the presence of a tumor, its nodular character if malignant and its mobility in the early stages; the feeling of a peristaltic wave from left to right in mechanical obstruction at the pylorus; the pylorus hardening under the hand in pyloric spasm, followed by a disappearance and then a reappearance of the tumor; the general outline of the dilated stomach to be felt in acute gastric dilatation or in a stomach artificially distended with gas or air, and many other points can be almost definitely settled by palpation. Bimanual palpation, with one hand in the loin and the other on the front of the abdomen, will often add to the information concerning a tumor or other associated condition, as, for instance, a movable right kidney dragging on the pylorus or a distended gall-bladder fixed by adhesions to the stomach.

Succussion is a modification of palpation frequently employed to elicit a stomach splash which, if present habitually, usually indicates pathologic dilatation, and which if present four to five hours after a full meal indicates motor inefficiency, or some obstruction at the pylorus, or both.

In perforating ulcer, the presence of free fluid in the peritoneum may be ascertained by flicking the abdomen with the finger-nail during palpation, when a communicated wave may be felt. The same method is useful in ascertaining the presence of ascitic fluid, which if present along with a tumor of the stomach is usually indicative of advanced cancer.

Eliciting certain tender spots, by palpation on the surface of the body (Figs. 422 and 423), may be of great assistance; for instance, tenderness in the superior abdominal region is suggestive of gastric ulcer and the site of tenderness to the left or right is some guide as to its position, especially when the rigidity of the corresponding rectus is taken into consideration. The most common site for tenderness in ulcer of the stomach is at the point marked on the diagram between the midline and the left costal margin; that for ulcer at the pylorus is usually on the right of the midline, and that for ulcer of the duodenum still more to the right and rather lower. In the dorsal region there is a well-marked tender spot 1 to 2 inches to the left of the spine opposite the ninth, tenth, and eleventh ribs, which is present in many cases of ulcer.

Percussion is useful in ascertaining the size of the stomach, the

resonance of which when not distended with food under normal conditions should not reach below a point midway between the ensiform cartilage and the umbilicus, though gastric resonance reaching to the

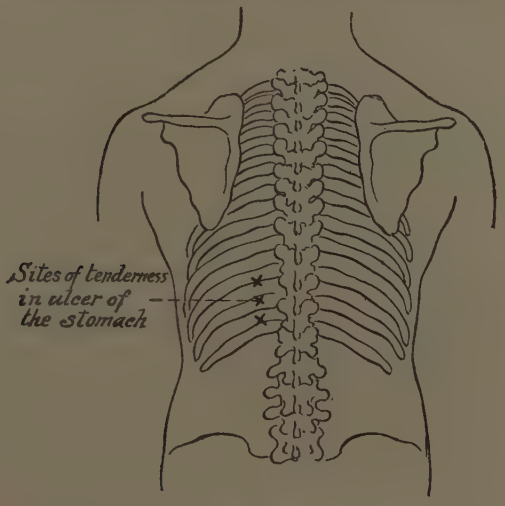

FIG. 422.

umbilicus does not necessarily mean the dilatation of disease. By means of percussion the size and shape of the stomach may be ascer-

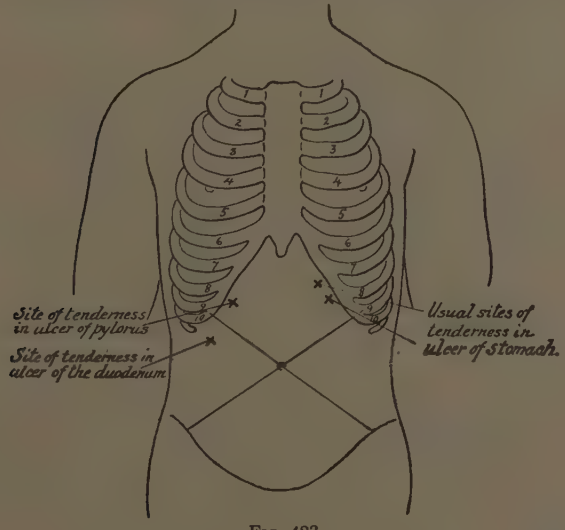
Site of tenderness in ulcer of pylorus
Site of tenderness in ulcer of the duodenum
Usual sites of tenderness in ulcer of stomach.

FIG. 423.

tained with the greatest accuracy, and in this way simple dilatation, dilatation of the dome of the stomach upward, hour-glass deformity, and gastroptosis may be readily demonstrated. It is more efficiently

carried out after dilating the stomach, either with air pumped through a tube or by distending with CO_2, either by giving carbonate of soda and tartaric acid in water in successive doses, or by giving a tumblerful or two of soda-water. If distention occurs after the administration of carbonate of soda alone, it usually indicates excess of acid in the stomach, which may point to hyperchlorhydria and ulcer. By percussion of the stomach with the patient upright, before and after drinking a measured quantity of water, the size and capacity of the stomach may be ascertained.

In the diagnosis between a gastric or a pancreatic tumor light percussion will reveal resonance, but deep percussion dulness in pancreatic growth, this being more marked on moderately distending the stomach with air or CO_2.

Percussion is also of use in ascertaining the presence of fluid in the peritoneum, whether from ascites or from extravasation; and in the diagnosis of subphrenic abscess, by showing the extent to which the liver is depressed by the fluid above it and by revealing a hyperresonant note above the liver if the abscess contains air and fluid, this being changed to a note of dulness when the patient is rotated on to the affected side.

Auscultation when combined with percussion may reveal the splashing sounds in gastric dilatation and the gurgling or metallic sounds in the cavity of a subphrenic abscess containing gas.

When the stethoscope is placed over the stomach and percussion is made by tapping a coin placed on the abdominal wall by means of another coin, the area of gastric resonance may be readily mapped out.

In a healthy person food occupies about four seconds in passing from the mouth to the stomach, but when there is stricture of the esophagus the time may be delayed for from fourteen to sixteen seconds; this can be readily ascertained by auscultating about 3 inches below the left scapula, at which point the gurgle or amphoric rushing sound can be heard when fluid enters the stomach. This may be important when the question of gastrostomy for stricture of the esophagus arises.

Instrumental Aids to Diagnosis.—In case of pending starvation from obstruction at the cardiac orifice, the question of gastrostomy will arise, but it must first be made clear that the obstruction is organic and not from mere spasm that might be overcome by milder means. For this purpose an esophageal bougie may be employed, and if this is arrested at the entrance to the stomach or just before, and if the obstruction fails to yield to gentle pressure sustained for a short time, the stricture is probably organic, and if slight bleeding results from the gentle use of a bougie, the stricture is probably due to cancer.

If the stricture occurs before middle age it may be desirable to give an anesthetic before finally deciding, in order to overcome spasm should that be the cause arresting the passage of a bougie.

Such a stricture may be examined directly by means of Killian's tube for esophagoscopy and the use of a forehead light.

Skiagraphy.—The Roentgen rays have a distinct rôle in certain

cases—*e. g.*, where foreign bodies have been swallowed, in ascertaining their position in the esophagus or stomach (*Cf.* page 791).

A further use has been made of the *x*-rays to ascertain the size of the stomach and the situation of the pylorus by the use of the screen, with the patient in the erect posture, after letting him swallow keratin-covered capsules containing bismuth, the covering of which is not dissolved by the gastric juice.

FIG. 424.

FIG. 425.

FIGS. 424 and 425.—NORMAN DALTON'S METHOD OF ASCERTAINING THE POSITION AND SIZE OF THE STOMACH BY MEANS OF THE X-RAYS AND A TUBE FILLED WITH SUBNITRATE OF BISMUTH.

Fig. 424, Gastrectasis from adhesions at the pylorus; Fig. 425, extreme gastrectasis. (The illustrations are negatives, and in both the white disc marks the umbilicus and the white lines the curve of the ribs. The tube is also white.)

Dalton and Reid[3] have made use of a flexible tube containing bismuth to show the outline of the stomach.

The digestive power of the stomach has hitherto been measured only by means of Ewald's test-breakfast, with the subsequent use of the stomach-tube or by the iodin or salol reaction of the urine as suggested by Sahli.

Schwarz estimates the digestive power of the gastric juice by making the patient swallow a pill of ⅓ to ½ ounce of bismuth subnitrate enclosed in an envelop made from the vermiform appendix of an animal. The time required for the digestion of the covering is then observed by watching it through the fluoroscope. In a healthy stomach the bismuth is diffused in seven hours; in cases of hyperacidity it is diffused in from two to five hours. An emulsion of bismuth has been used by C. B. Worden for diagnostic purposes.

Electric illumination may sometimes be useful in demonstrating the size of the stomach and in showing the position of a tumor, which appears as a dark patch in a light field. It is easily applied by letting the patient drink sufficient water when the stomach is empty to fill it moderately. A bougie is then passed with a small electric lamp near its extremity. It is best used in the erect posture and in a dark room.

Fluorescent Media for Transillumination of the Stomach.—In a paper on "Dilatation of the Stomach and Gastroptosis," Kemp,[4] holding that transillumination of the stomach is the ideal method of ascertaining its limits, advocates the introduction of fluorescent media into the stomach before the electric lamp is passed, by which he has found that the brilliancy of the transillumination is increased over one-half. The principal medium is bisulphate of quinin in the strength of 10 gr. to 1 pint of water with, preferably, the addition of 5 minims of dilute phosphoric acid or sulphuric acid. The fluorescence is a pale violet. Increased acidity intensifies its action and fluorescence at once disappears if the solution is rendered alkaline. The other medium is fluorescin, used by ophthalmic surgeons to detect ulcers of the cornea. In an alkaline and alcohol medium it gives a green fluorescence. The hydrochloric acid of the stomach is first neutralized by giving 15 gr. of sodium bicarbonate dissolved in 8 ounces of water; or 1 or 2 ounces of lime-water, and then a second draught consisting of 8 ounces of water in which are dissolved 15 gr. of sodium bicarbonate, 1 dram of glycerin, and ⅛ to ¼ gr. of fluorescin. By this means he has been able to transilluminate the stomachs of persons with thick abdominal walls, otherwise a matter of difficulty.

The **removal of a portion of mucous membrane** for microscopic examination by means of specially constructed forceps need only be mentioned to be condemned as unnecessary and dangerous.

The **exploring syringe** may afford useful aid in the diagnosis of subdiaphragmatic abscess.

Gastric lavage serves a very useful purpose for ascertaining the quality of the gastric secretion after a test-meal and the character of the retained gastric contents in chronic dilatation, and also in estimating the motor activity of the stomach.

Leube's method for ascertaining the motor activity of the stomach consists in washing out the stomach at various times after a good meal—¼ pound of freshly minced meat with some bread. Within six hours the stomach should be empty, but in dilatation or other con-

ditions in which the motor activity of the wall of the stomach is impaired, some food may be found many hours later.

In cases of dilated stomach, where the succussion splash is well marked and there is no vomiting, it is desirable to syphon off the contents in order to ascertain the presence or absence of free HCl, lactic acid, sarcine or yeast fungi, and other abnormal contents of the stomach. The motor activity of the stomach may be also ascertained by Ewald's test* of administering salol, which is not split up in the stomach, but which breaks up on coming into contact with the alkaline pancreatic juice. The salicyluric acid resulting is excreted in the urine, where it can be readily detected by the addition of neutral ferric chlorid solution, a violet coloration occurring.

Several instruments have been invented to test graphically the motor activity of the stomach which, though valuable for physiologic experiments, are not reliable in practise.

In **chemical reactions** for the diagnosis of malignant disease of the stomach[2] the relative abundance or absence of free HCl has been pointed out by Ewald as being of importance. In order to determine its existence, the patient should take a test-breakfast consisting of a cup of weak tea and a little dry toast. An hour later the stomach-tube should be passed and the contents of the stomach drawn off. These are to be tested by Günsburg's test for free HCl.

The absence or deficiency of free HCl occurs in several morbid states, but its presence is a strong point against a diagnosis of malignant disease of the stomach. Hyperacidity, on the other hand, is as characteristic of ulcer as diminished acidity is of cancer. The mere presence of an acid reaction should not be held as proving the presence of free HCl, since this may be caused by acid salts or by free organic acids, especially lactic acid. This can be recognized by Uffelmann's test. The presence of lactic acid and the absence of free HCl are strongly suggestive of cancer.

Osler[5] states that in 84 cases of cancer of the stomach out of 94 examined, free HCl was absent.

Examinations of Vomited Matters.—With regard to vomiting, the first thing to consider is the quantity vomited at one time. Nurses should be trained to estimate this carefully and also always to preserve specimens. In dilated stomach vomiting usually does not occur more than once daily, sometimes only every second or third day, and the quantity at any time is correspondingly large.

In ulcer of the stomach a considerable portion of the last meal may be brought up within an hour or two of its ingestion, and the pain it has caused be thereby relieved.

The smell should be considered, a yeasty smell being characteristic of dilatation of the stomach; a habitually fetid odor, of cancer of the stomach; and a feculent odor, of intestinal obstruction.

Vomit is usually acid in reaction; but it may be alkaline in some cases of chronic dyspepsia or when there is much blood present.

* The reader is referred to the Bibliography for this and other tests mentioned.

The most important abnormal constituent of vomit is blood. In large quantities its nature is obvious and is suggestive of simple ulcer, but in cirrhosis of the liver profuse hematemesis may occur owing to rupture of dilated veins. In smaller quantities the vomit has a characteristic dark appearance, resembling coffee-grounds, which may be due to cancer or simple ulcer. When the presence of blood in vomited matter is doubtful, the most reliable guide is the hemin test.

In cancer of the stomach blood is frequently present in the vomit—often in small, sometimes in considerable, only rarely in large quantity.

Pus is sometimes, but not often, vomited. In considering both pus and blood in a fluid said to have been vomited, it must be remembered that when large quantities of fluid are expelled from the lungs—*e. g.*, on the rupture of an empyema into the lung or a profuse hemoptysis—the sensation to the patient is often as if vomiting had occurred. The presence of food and the general absence of frothiness will help to distinguish true vomit, while vomited blood is generally much darker than blood from the lungs, but the only reliable way to make the distinction is to inquire carefully into the facts of the occurrence. Pus in the vomit may arise from an empyema of the gall-bladder or a pancreatic or other abscess bursting into the stomach or esophagus.

Examination by the microscope of vomited material is usually of secondary importance, but it sometimes affords great assistance, as in case of a subdiaphragmatic abscess bursting into the lung, where the presence of half-digested muscular fibers and the absence of elastic tissue distinctly proves the source of the pus to be the stomach and not an abscess of the lung or an empyema; and in some cases of cancer, where portions of growths or groups of cells are occasionally obtained by means of lavage. In dilatation of the stomach the sarcina ventriculi is frequently to be seen, together with yeast cells. In cancer, where macroscopically there is no evidence of blood, red blood-curpuscles may often be found on microscopic examination.

A diagnosis of the position of a gastric tumor has been claimed by Glaessner by means of an examination of the stomach contents. Having determined that the gastric mucous membrane can be divided into two physiologically distinct segments, the fundus, which has a large supply of glands, and the pylorus, which has but few glands, Glaessner[6] described how the localization of tumors can be made.

Examination of the blood, as a rule, shows the changes found in secondary anemia. Beyond this, the information given by an examination is of doubtful value.

Krokiewicz states that there is no change in the red blood-corpuscles. In 13 cases digestion leukocytosis was absent. Krokiewicz agrees with Lowitt that this sign is "of equal value with the absence of HCl and the presence of lactic acid." In nearly all cases the alkalinity of the blood was lessened. Osler and Macrae come to the following conclusions:

1. Neither an increase of the leukocytes nor special variations in the forms appears to be of any moment in the diagnosis of cancer of

the stomach. 2. The presence or absence of digestion leukocytosis is too uncertain to be of much assistance in diagnosis.

According to Lindner and Kuttner, absence of digestion leukocytosis is noticed rather more frequently in malignant than in simple disease. Hartmann and Silhol,[7] after careful research, have become convinced that in cancer of the stomach an examination of the blood is more likely to prove useful than a chemical investigation of the gastric contents.

Exploratory Incision.—Although exploratory incision for the purpose of making a diagnosis is, as a rule, undesirable, in certain cases the operation is not only justifiable, but strongly to be urged. For instance, when cancer of the stomach is suspected, but the diagnosis cannot be verified by ordinary methods; for an aseptic celiotomy is not dangerous, and it is clearly proved that in the surgical treatment of cancer the earlier an operation can be performed the greater will be the chance of radical cure, whereas if a diagnosis of the disease be not made until a tumor can be felt, it is, as a rule, too late for a radical operation.

An exploratory operation may also be required in certain cases of palpaple tumor of the stomach in which it is just possible that the growth may be amenable to surgical treatment, but it cannot be said beforehand whether the lymphatic glands are too extensively involved or the disease has so far invaded the adjoining tissues that removal of the growth would be useless, and when a gastro-enterostomy or a jejunostomy may have to be performed as palliative procedures.

A third condition in which an exploratory operation may be required is in some cases of abdominal injury, either gunshot or stab wound, or even in an injury without external wound, in which the severe shock, the vomiting of blood, and the general condition of the patient may lead to a suspicion of direct injury to the stomach, the repair of which at the earliest possible moment is very desirable.

At times all the symptoms of perforated ulcer may be present without a previous history of ulceration, and the abdominal pain may be so generalized that it is impracticable without serious delay to make out exactly what accident has occurred. Under such circumstances an exploratory operation may sometimes be required in order to ascertain the presence or absence of perforating ulcer. (For the technic of such operations see the chapter on the Technic of Abdominal Surgery, p. 706.)

GASTROPTOSIS.

Glénard, of Lyons, in 1885, described a condition of the abdominal viscera in which the folds of the peritoneum or the ligaments supporting them are lengthened, thus allowing the various organs to slip below their normal position and to have a range of motion beyond what is natural. When the stomach is thus displaced downward it is known as gastroptosis.

The condition may be congenital or acquired. Occasionally it

appears to be dependent on tight lacing, but more frequently on emaciation associated with loss of tone of the abdominal muscles. Although gastroptosis is usually associated with movable kidney and other splanchnoptoses, it may exist independently.

The accompanying diagram shows the condition at a glance, and it also shows how the dragging of the distended stomach may readily cause a kink at the pylorus and so lead to irregular obstruction at the pyloric outlet, to acute dilatation, or even to a more or less complete volvulus of the entire organ.

The frequency of gastroptosis was shown by Glénard, who observed it 400 times in 1300 patients.

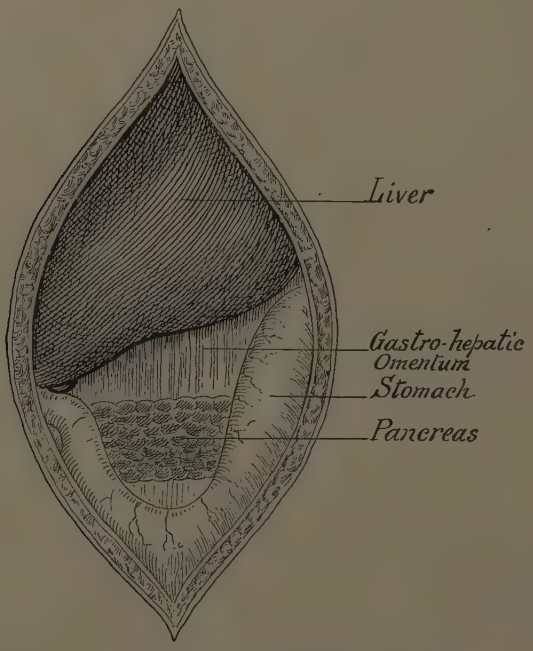

FIG. 426.—GASTROPTOSIS.

Fortunately, as a rule, it produces no symptoms and may only be discovered in the course of clinical investigation for other diseases; though in exceptional cases the symptoms may be distressing and in certain cases even dangerous.

The usual symptoms are those of atonic dilatation of the stomach characterized by gastromotor insufficiency; and it is generally accompanied by neurasthenia.

These patients are always thin and spare, often tall, and nearly always of a neurotic temperament; they complain of indigestion characterized by discomfort or pain after eating, flatulency, fulness in the abdomen, and faintness at times when distention is marked. Nausea and vomiting may be complained of and a stomach splash can usually be obtained low down in the abdomen some hours after a meal.

In the more severe cases vomiting occurs several times a day and the patient gradually becomes thinner, feebler, and more anemic, so that unless relief be given chronic invalidism ensues. Occasionally symptoms may occur characterized by acute distention of the stomach and pressure upward on the heart, leading to fainting and failure of the pulse, a condition which for a time appears to be very alarming, but which usually passes away after free eructation of inodorous gas. It is doubtless due to kinking of the pylorus or to spasm of the pyloric sphincter.

The physical signs of gastroptosis are readily made out by distending the stomach with air through a stomach-tube, or by giving carbonate of soda and tartaric acid in separate doses so as to liberate carbonic-acid gas.

Without artificial distention, however, it is usually easy to make out the boundaries of the gastric resonance in well-marked cases and to feel the pancreas above the lesser curvature.

Sometimes the stomach may be almost vertical in direction, at other times the pylorus may almost retain its position and allow the body of the organ to sag in the center, leaving the pancreas exposed, as shown in Fig. 428. In the latter class of cases retention is much more liable to occur than in the former.

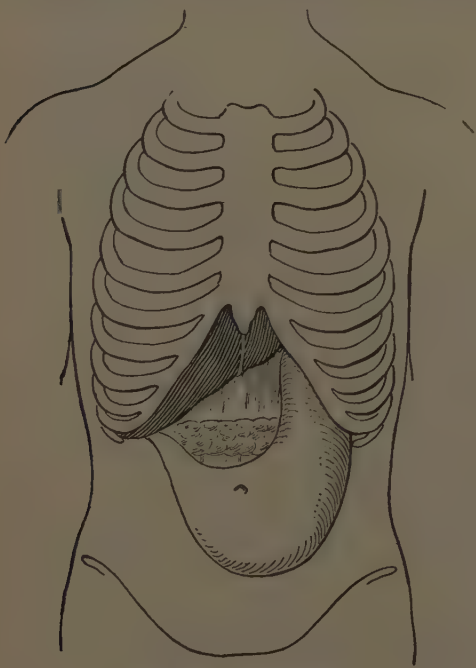

FIG. 427.—GASTROPTOSIS.

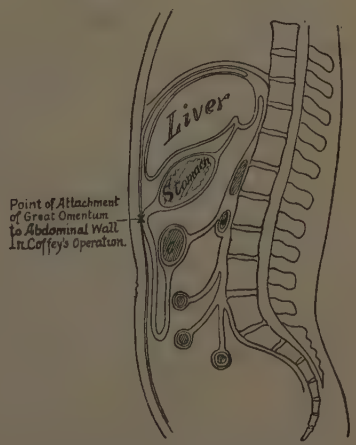

FIG. 428.—COFFEY'S OPERATION FOR GASTROPTOSIS.

Great mobility of the kidney, especially of the right kidney, is usually associated with gastroptosis. In some cases hepatoptosis and in others enteroptosis can be made out at the same time. It is usually in these cases easy to make a physical examination, as the abdominal walls are relaxed and generally free from tenderness.

Treatment.—In the greater number of cases general treatment answers all the indications; regulation of the bowels, abdominal massage, gymnastic exercises to strengthen the abdominal muscles and increase intra-abdominal pressure, the avoidance of tight lacing, the wearing of braces instead of stays or of a belt that would constrict the waist, the use of strychnin or other tonics that may be indicated, a nourishing diet, and the avoidance of long hours or excessive fatigue are all useful.

At times the rest may be advantageously combined with massage. Support to the abdominal viscera by wearing a well-fitting abdominal belt is often of great service.

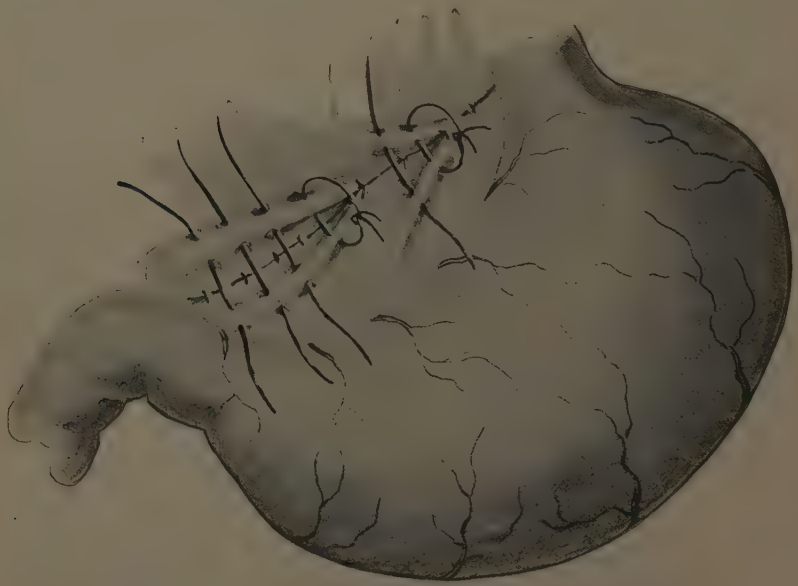

FIG. 429.—BEYEA'S OPERATION FOR GASTROPTOSIS. (Moynihan.)
The first layer of sutures completed, the second and third being introduced.

When the stomach is much dilated, especially if the dilatation is associated with catarrh, but without actual stenosis of the pylorus, gastric lavage may be of service.

Should all these means fail, operative treatment may be called for. Several operations have been suggested.

Duret[8] performed gastropexy by fixing the pylorus and lesser curvature to the abdominal wall, but this method is not to be recommended, as gastric adhesions to the abdominal wall are quite capable of producing serious symptoms.

Coffey[9] suggested that the omentum as it comes off from the greater curvature of the stomach should be stitched to the parietal peritoneum about 1 inch above the umbilicus, in order to sustain the stomach, as it were, in a hammock. It has been put to the test in 2 cases which appear to have been satisfactory. Fig. 428 illustrates the method.

Beyea's Operation.—The only method which seems at all worthy

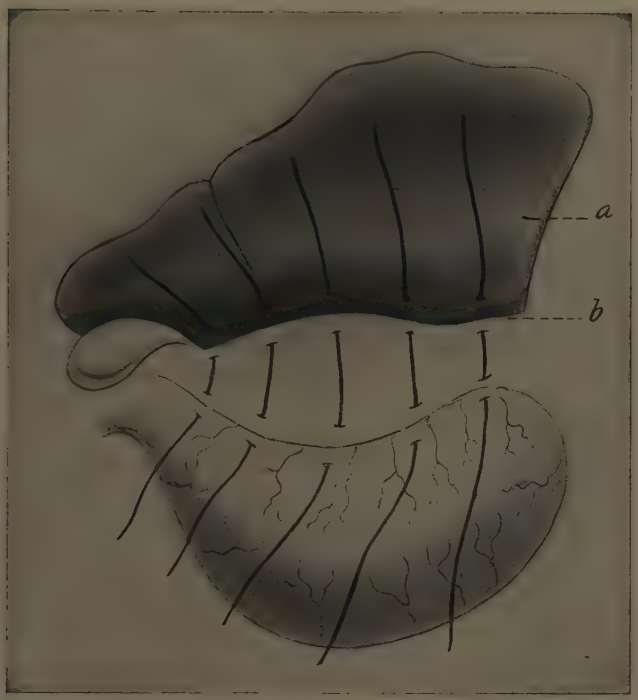

FIG. 430.—*a*, LIVER; *b*, JUNCTION OF GASTROHEPATIC OMENTUM WITH LIVER. (Eve.)

of support is an operation suggested by Bevea.[10] He shortens the suspensory ligaments of the stomach by passing a series of ligatures

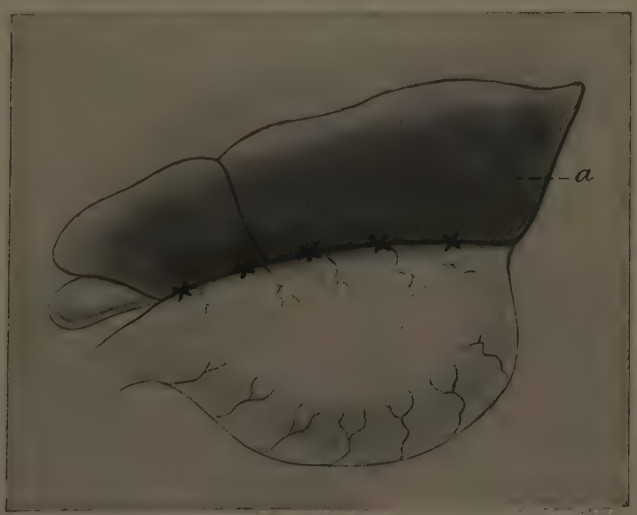

FIG. 431.—LIVER TURNED UP. SUTURES SHOWN IN FIG. 430 NOW TIED. (Eve.)

through the gastrohepatic omentum. The sutures are applied in three rows (see Fig. 429).

In this way the normal mobility of the stomach is not interfered with and no abnormal attachment of the stomach to the abdominal wall is made. Beyea[12] reported having performed his operation upon 8 patients; all except 1, an extremely neurasthenic girl, had improved very remarkably, had gained weight, and been relieved of all gastric symptoms.

Bier has suggested a modification of this operation by attaching the pyloric end and lesser curvature of the stomach to the capsule of the liver; and although this modification would seem undesirable, Bier[11] has reported 4 apparently satisfactory cases, and Frederick Eve[13] has also described cases operated on by this method (Figs. 430 and 431).

CONGENITAL HYPERTROPHIC STENOSIS OF THE PYLORUS.

According to Osler[14] the earliest record of this disease is a case described by Bardsley in 1788, under the title of "Scirrhus of the Pylorus in an Infant." In 1888, Hirschsprung[15] drew attention to the subject anew, and Thomson,[16] Cautley, and Clinton Dent[17] have recently discussed it fully.

Until comparatively recently the disease was considered rare, though of late so many cases have been recorded that it would appear as if it or allied conditions were extremely common, and Sarvonaut[18] has collected no less than 115 cases.

While some authorities speak of the disease as curable by medical treatment, others state that it is fatal unless surgically treated. It is quite clear, therefore, that at least two different classes of cases are referred to under the same name: one, simple spasm of the pylorus associated with some hypertrophy of the pyloric end of the stomach, not simply of the pyloric ring; the other, in which the spasm and hypertrophy are associated with a hyperplasia in the wall of the stomach itself. The latter forms a sausage-shaped swelling fully 1 inch in length and is quite different from the ring of hypertrophied muscle, triangular in section, seen in simple spasm of the pylorus.

The elongated pyloric swelling obstructing the outlet of the stomach is known as "congenital hypertrophic stenosis of the pylorus," of which nearly 100 cases have been recorded, though doubtless there are many cases unreported of infants whose deaths are ascribed to atrophy, marasmus, debility, or inanition, that were really instances of this affection. The subjects of this disease probably nearly all die before the fourth month of life, if not operated on.

The **symptoms** are quite characteristic and show themselves from within a few days to three weeks after birth by vomiting, loss of weight, and constipation. The physical signs are dilatation of the stomach, with visible peristalsis from left to right, and the presence of a sausage-shaped tumor. The progress of the disease is rapid, and from being possibly at first a well-nourished infant, the patient rapidly becomes emaciated. Unless operation be performed, the case usually ends in death from starvation. If the case be one of simple spasm of the

pylorus, lavage of the stomach and careful feeding may bring about recovery, as in cases reported by Batten,[19] Blaxland,[20] and Still.[21]

The morbid appearances are those of a cylinder, hard and incompressible, which on section shows the walls of the pylorus and the adjoining pyloric end of the stomach to be greatly hypertrophied. The pyloric canal is filled by longitudinal folds of mucous membrane and the lumen may be so small as only to permit the passage of a small probe. The circular muscular fibers are chiefly affected in the hypertrophy or hyperplasia, but the longitudinal fibers in some cases participate. As a rule the mucous and serous coats are unaffected.

Etiology.—While Thomson thinks the hypertrophy of the pylorus is secondary and due to congenital gastric spasm, Cautley holds the view that the hyperplasia is primary and due to a redundance of growth in the pylorus.

Treatment.—In the well-marked cases surgical treatment alone offers a probability of relief or cure, and for this pylorectomy, gastro-enterostomy, pyloroplasty, and pylorodiosis have been performed in different cases.

Pylorectomy is an unnecessarily severe procedure and not to be recommended.

Gastro-enterostomy is the operation preferred by many able surgeons. It is certainly less liable to be followed by relapse than is pyloroplasty, and if properly done is not more severe.

So far the mortality has been very heavy (25 cases—11 recoveries), but as many of the cases were almost moribund at the time of operation it can hardly be blamed for the fatalities. Of those recovering, the after-histories of 9 of the cases are excellent (Paterson[22]). Sarvonaut, in his analysis of 115 cases, prefers treatment by gastro-enterostomy.

Pylorodiosis, or stretching the pylorus, or Loreta's operation, has given better immediate results (21 cases—15 recoveries). A number of the patients have remained well, but a considerable number have relapsed, and in one a gastrojejunostomy was subsequently done successfully.

The disadvantages of stretching the sphincter are the uncertainty of the operation and the fear of extensive laceration, which may lead to immediate danger or to subsequent contraction of the scar. Of 9 cases of pyloroplasty collected by Paterson, 6 recovered, of these 5 have remained well. Seeing, however, that the dilated stomach and the duodenum of infants are mobile and can be fairly easily approximated, the operation of Finney may prove to be better, as it gives a much larger opening than simple pyloroplasty and is less liable to contract.

Nicoll[23] has reported 6 cases of operation on infants, from six to ten weeks old, all being weak and emaciated. The operation performed by him was the V-Y modification of pyloroplasty. In 4 of the cases the V incision only penetrated the serous and muscular coat and was closed as a Y incision by a single row of sutures, the operation being combined with divulsion by means of a pair of forceps passed through an incision in the anterior wall of the stomach near the pylorus. In the 2 remaining

cases the V incision was carried through into the lumen of the pyloric passage and was closed as a Y incision by two rows of Czerny-Lembert sutures. Clamps were used on the stomach and duodenum in all the 6 operations; 5 recovered and are apparently cured.

Each case must, however, be a law to itself, for much will depend on the extent of the tumor, the mobility of the parts, and the condition of the infant; doubtless, therefore, each surgeon will select that operation which at the time he feels he can perform with the most expedition and safety in order to short-circuit the obstruction or otherwise remove it.

A condition of dilated stomach due to pyloric narrowing is not infrequently met with in young adults, leading to serious deterioration of health, without any history of pyloric ulcer or other disease ordinarily leading to pyloric stenosis.

Landerer, quoted by Maier,[24] has described a number of these cases occurring at various ages, mostly in young adults, and Maylard[25] has also drawn attention to the same condition and described 7 cases occurring in patients from twenty to thirty years of age, where chronic relapsing gastric catarrh due to a congenital narrowness of the pylorus with secondary dilatation had been cured by gastrojejunostomy.

I have seen several of these conditions in young adults, and in the literature of gastric diseases many cases have been recorded. In all the cases in young adults, the patients give a history of having had repeated attacks of indigestion with pain and fulness after meals associated with weakness, want of energy, and loss of flesh. After rest, careful dietetic treatment, and at times regular lavage, the patients have been restored for a time to health to undergo a relapse after slight irregularities in diet or after any mental or bodily fatigue. The gastric dilatation soon becomes a prominent sign and the relaxed abdominal walls enable a stomach splash to be obtained at any hour of the day, long after the stomach ought to have emptied itself. Repeated relapses induce a condition of ill health which predisposes to pulmonary or other disease that may end in early death unless the patient be cured by surgical treatment, of which gastrojejunostomy is the best and most satisfactory operation.

CONGENITAL ATRESIA OF THE PYLORUS.

Congenital atresia may be found in any part of the alimentary canal, from the pharynx to the anus, evidently due to arrested development.

In all the recorded cases the malformation has ended in death. If the condition be recognized sufficiently early it should be amenable to surgical treatment either by a gastroduodenostomy or a gastrojejunostomy. Hitherto, however, no operation for the condition has been recorded.

HERNIA OF THE STOMACH.

This condition is thoroughly considered under the section on Hernia (Vol. IV.), and, therefore, need not be dwelt upon in this part of the work.

GASTRIC VOLVULUS.

Volvulus of the stomach is a rare accident, only a few cases having been recorded, 3 of which were associated with diaphragmatic hernia.

Under ordinary anatomic conditions the occurrence of gastric volvulus or a twist of the stomach on its own axis is extremely unlikely, probably impossible; but under the altered anatomic relations found in gastroptosis it may occur.

Wiesinger[27] has related 1 case of acute dilatation of the stomach in which mechanical blocking of the orifices of the viscus by rotation seemed to be responsible for the distention.

Four cases followed an injury; 2 appeared rapidly after an abdominal injury, and 1 occurred as a later complication of an injury to the lower dorsal region of the spine.

Symptoms.—The symptoms are characterized by sudden pain and collapse with a profound sense of depression and sickness, but with an inability to vomit or to belch. If relief is not afforded by early operation, death is inevitable.

The physical signs are those of a tense and tender cyst on the left of the upper abdomen filled with air which cannot be forced out by moderate pressure.

Treatment.—Immediate laparotomy with untwisting of the volvulus and replacement of the stomach in its usual position is demanded, but in order to prevent a recurrence of the accident, Beyea's operation for shortening the gastrohepatic ligament should be performed (see Gastroptosis).

If a gastric volvulus associated with diaphragmatic hernia could be discovered before the symptoms of strangulation had become acute and before the patient was moribund, reduction of the hernia and possibly suture of the hernial aperture might be carried out with some hope of success.

In a most valuable paper Knaggs[29] refers to 3 cases of volvulus of the stomach occurring as a complication of diaphragmatic hernia.

INJURY OF THE STOMACH.

As external injuries of the stomach, such as gunshot wounds, stab wounds, etc., are considered in another portion of this work, it is necessary here only to consider those injuries which may be said to occur from within the stomach.

Spontaneous rupture of the stomach from overdistention, quite independent of ulceration or other disease, has been frequently recorded.

Recovery probably never occurs spontaneously in this class of cases. Abdominal section followed by peritoneal cleansing and suture of the opening afford the only chance of cure.

Perforation from within may occur in another class of cases, as in the case of "sword swallowers."

The wounds caused by perforation in the case of sword and knife swallowers are not necessarily immediately fatal if no large vessel is

wounded and the stomach is empty at the time of injury, though in any such case immediate laparotomy and suture of the visceral wounds is imperative, as diffuse peritonitis is certain to ensue. Cases are on record, however, in which gradual perforation by a foreign body in the stomach has occurred, leading to adhesive peritonitis and the formation of abscess in the abdominal wall, which on being opened has afforded a safe exit for the irritant.

Traumatic Ulcer of the Stomach.—The occurrence of this condition was first noticed by Pinel in the early part of the last century and a full record of cases may be found in a "Thesis" by Dumeny.[31]

It may be caused by a blow over the epigastrium or by a squeeze between the buffers or between the opposing seats of a railway carriage in an accident, as in a case recorded by Rendu; or the injury may be from within from a foreign body swallowed accidentally or intentionally. It has also followed a stab or a bullet wound in which the manifest wound was repaired, though the non-perforating injury to the posterior wall of the stomach which was not noticed at the time ended in traumatic ulcer and in fatal hematemesis (Forgue and Jeanbrau[32]).

These ulcers are usually superficial, but may give rise to severe pain and serious or even fatal hematemesis; they may also end fatally by sloughing and perforation or they may become chronic and cause stenosis of the pylorus (Michaelis) or hour-glass contraction (Potain). The actual cause is probably hyperchlorhydria due to irritation aroused by the lesion.

The history of accident followed shortly by pain after food and by hematemesis afford the chief diagnostic points.

Treatment is by absolute rest in bed with rectal feeding for some days, followed by milk and lime-water given every hour in 2- to 4-ounce doses when the patient is awake, for another week, and then by soft food for a month. If at the end of that time the symptoms persist, or later the disease recurs, a gastro-enterostomy by securing physiologic rest and relieving the hyperchlorhydria, as a rule, will bring about a cure.

If, however, the ulcer be in an easily accessible situation, excision of the injured area may be performed.

Injury due to the Swallowing of Caustic Fluids.—Soap, lyes, hydrochloric acid, carbolic acid, and other strong acid or alkaline fluids may be swallowed by accident or with suicidal intent. The immediate and remote effects will largely depend on the quantity as well as on the state of dilution. The mouth, pharynx, lower end of the esophagus, and pyloric end of the stomach are the parts most severely affected, the body of the stomach and the middle part of the esophagus frequently escaping injury unless a large quantity of the caustic be swallowed.

In severe cases the shock is profound and may be followed by prolonged collapse; pain is usually severe in the mouth, along the esophagus, and at the epigastrium, which is exquisitely tender to pressure. The mouth and throat show the effects of the corrosive and may prevent swallowing; vomiting usually occurs, the vomit containing

altered blood in the shape of coffee-ground material; thirst and restlessness are marked; chest symptoms, bronchitis, and pneumonia may supervene, and if the pharynx has been much affected danger may arise from edema glottidis.

In some cases where the damage has been slight recovery occurs without any serious after-effects, but in other cases besides injuries to the mouth, pharynx, and esophagus, the stomach may be left in a state of ulceration that may in itself prove dangerous from hemorrhage or perforation, or which may end in serious deformity from contraction when the ulcers heal. Thus, pyloric stenosis with subsequent dilatation of the stomach or hour-glass contraction may occur, or stricture of the cardiac orifice may prevent food entering the stomach. The perigastritis set up at the time of the accident may lead to extensive peritoneal adhesions.

Treatment.—The immediate treatment will depend on the nature of the caustic that has been taken; alkalies for acids and acids for alkalies will usually have been given before the surgeon sees the case, as also will emesis have been induced by large doses of salt and water.

Absolute abstention from all food should be advised and for some days all feeding should be by nutrient enemata. In order to keep the ulcerated surfaces as clean as possible the mouth must be washed and the throat gargled or sprayed with some mild antiseptic, such as boric acid. When feeding is begun, the foods should be liquid or semifluid and sterilized by boiling, and only when pain and tenderness at the epigastrium are ceasing or have disappeared should pulpy foods or semisolids be allowed.

If the case be a severe one, associated with extensive ulceration or sloughing in the mouth, throat, esophagus, and stomach, it may be necessary to give absolute rest to the upper digestive tract for a longer time than life can be supported by rectal feeding alone, and then the operation of jejunostomy will prove of extreme service. In 1 of my cases life was prolonged in comfort for twelve months after a jejunostomy (see Jejunostomy, p. 942). Later, according to the position of the stricture, other operations may be called for in certain cases.

GASTROTOMY.

By gastrotomy is understood the operation of opening the cavity of the stomach temporarily, gastrostomy being used when the opening is intended to be more permanent. It may be required under the following circumstances:

(1) As a simple exploratory operation for ascertaining the presence or site of an ulcer of the stomach. (2) In case of hematemesis, for discovering and locally treating a bleeding ulcer. (3) For the removal of foreign bodies from the stomach. (4) For the removal of foreign bodies from the lower end of the esophagus. (5) For dilating a stricture of the esophagus. (6) For dilating a stricture of the pylorus, as in Loreta's operation. (7) For the removal of a polypus or other tumor

projecting into the stomach. (8) For dilating the cardiac orifice in cardiospasm.

The abdomen is opened and the stomach is drawn forward and surrounded by sterile gauze. The opening into the stomach is made through the anterior wall, and if made at a right angle to the longitudinal axis very few vessels will be wounded, but if any should be divided they will, of course, be immediately ligated. On retracting the edges of the incision the contents, if any, must be mopped or syphoned out unless they have been pushed on into the duodenum before the stomach was opened. The interior of the stomach may now be explored either by means of a Ferguson speculum introduced through the opening, when the interior can be lit up by a forehead electric light, or a cystoscope may be introduced so as to illuminate the whole interior of the organ.

If the gastrotomy has been performed for ulcer or for hemorrhage, it may be necessary for treatment, should the ulcer be on the posterior wall, to make a slit through the transverse mesocolon, so that the index- and middle fingers of one hand may be passed through this, and by pressing on the posterior wall make prominent any part of it. In this way an ulcer or a bleeding point can be fully exposed and treated; or should a polypus or other tumor be discovered it may be brought up and excised or otherwise attended to.

After the interior of the stomach has been treated according to the circumstances of the case, the gastric wound may be closed by a fine continuous chromicized catgut suture to unite the mucous membrane and submucous coat, the serous and muscular coat being brought together either by a fine continuous silk or Pagenstecher suture. If it is thought that there is any weak point in the suture line a few additional Lembert sutures may be applied for greater security. The parts that have been exposed may then be gently wiped with sterile salt solution.

For the first twenty-four hours it is better to feed by enemata, merely a teaspoonful of water occasionally being allowed by the mouth. On the second day this may be increased to a tablespoonful or even an ounce at a time; on the third day a little Benger's food, broth, or jelly may be given; after a week it will be safe to give fish, pounded meat, and other substantial diet.

FOREIGN BODIES IN THE STOMACH.

All the principal museums bear testimony to the infinite variety of foreign bodies that may be found in the stomach, some of which have been swallowed by the insane, in other cases by accident, and occasionally intentionally as a means of livelihood for the amusement of the public.

The foreign bodies in the stomach are of great variety—knives, open or shut, spoons, forks, nails, pieces of wood, razors, stones, needles, safety-pins, ordinary pins, false teeth, buttons, coins, keys, broken glass, hair-balls, etc. If the foreign substances are rounded and not irritating they may remain for months or even years.

Friedenwald and Rosenthal[33] have collected from literature a series of 90 cases of gastrotomy for the removal of foreign bodies from the stomach. In the 90 cases one foreign body was found in 68 instances, and more than one in the remainder. In the series of 90, adhesions were found in 13 cases. In 6 an abscess had pointed on the anterior abdominal wall. In 3 perforation occurred and resulted fatally.

Symptoms.—The symptoms are very variable. In some cases patients complain of chronic indigestion with pain after food and occasional vomiting. If ulceration has occurred the vomit may be tinged with blood, and I have seen fairly free hematemesis result. In some cases local peritonitis with severe pain is set up, and there are on record a number of cases in which perforation and fatal peritonitis have occurred. In the case of hair-balls or other large foreign bodies a tumor may be felt.

Since the introduction of the Roentgen rays, a new means of diagnosis has been added and there is now no difficulty in ascertaining the presence and the situation of any metallic body in the stomach.

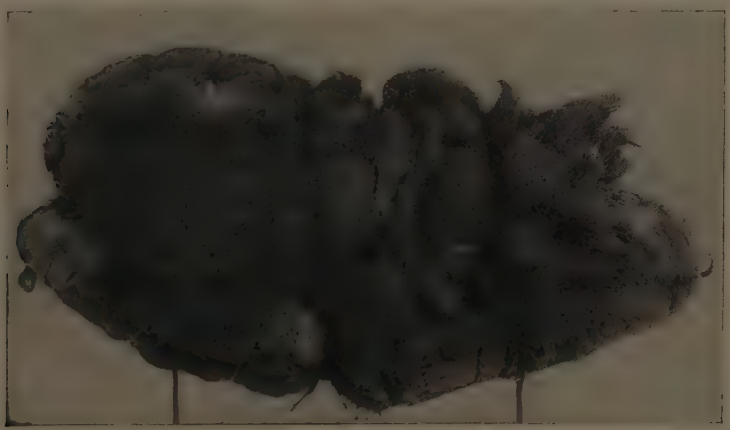

FIG. 432.—A ROLL OF BLACK HUMAN HAIR 12 INCHES LONG, WEIGHING 5 LB., 3 OZ., REMOVED SUCCESSFULLY FROM A GIRL OF TWENTY.
(*Lancet*, 1895, vol. i., p. 1581. No. 2381, Royal College of Surgeons' Museum.)

The indication for operation is the presence of a foreign body which can neither be safely dissolved nor allowed to pass through the intestines and which is producing or is likely to produce serious symptoms. The removal by gastrotomy of foreign bodies lodged in the stomach has been attended with great success.

Friedenwald and Rosenthal (loc. cit.) divided the 90 operations that they have been able to collect into two series. In the pre-antiseptic days there were 19 cases with 15 recoveries; since the improvements of surgery brought about by asepsis, there have been 71 cases with 7 deaths.

Appended are photographs of specimens taken from the Hunterian Museum at the Royal College of Surgeons.

In a case of my own reported in the *Lancet* for November 3, 1894,

there were 42 cast-iron garden nails $1\frac{5}{8}$ inches long, 93 brass and tin tacks from $\frac{1}{2}$ inch to 1 inch long, 12 large nails (some brass-headed), 3 collar studs, 1 safety-pin, and 1 sewing-needle. It is interesting to

FIG. 433.—STOMACH FROM A WOMAN AGED FORTY-ONE, WHO HAD SUFFERED FROM HEMATEMESIS AT SEVENTEEN AND SEVERAL TIMES LATER, CAUSED BY NEARLY A POUND OF PINS IN THE DUODENUM DISPLACING THE PYLORUS BEHIND THE PUBES AND CAUSING OBSTRUCTION.
(No. 2379, Royal College of Surgeons' Museum.)

FIG. 434.—FOREIGN BODIES SUCCESSFULLY REMOVED BY THE AUTHOR FROM THE STOMACH OF A GIRL AGED TWELVE.
(Royal College of Surgeons' Museum.)

notice that this patient is now in good health eleven years after operation.

Gastrotomy for the removal of a polypus or other growth in the stomach is an operation that may occasionally have to be done, but as simple tumors of the stomach are somewhat rare, it is scarcely likely that the operation will be more than an occasional one.

ULCER OF THE STOMACH.

Ulcer of the stomach in the more advanced cases produces a loss of substance of any or of all the coats of the viscus.

Excluding malignant, tuberculous, and syphilitic ulcers, the following classification embraces the various forms of simple ulcer:

1. *Erosions.*—Of these Dieulafoy has described two varieties:

(*a*) *Simple erosions*, consisting apparently of mere abrasions of the surface epithelium, which, though so small as to be scarcely perceptible to the naked eye, may give rise to most alarming hemorrhage. On the post-mortem table abrasions of the kind may be easily overlooked, as they are not accompanied by induration, but when hemorrhage is going on the mucous membrane seems to be studded with numerous bleeding points.

(*b*) *Exulceratio Simplex*.—In the form to which Dieulafoy applied this term the lesions are rather more extensive and the surface layers are removed to such an extent that the arterioles running under the muscularis mucosæ are exposed. This form of ulceration may give rise to terrible hemorrhages that may prove rapidly fatal unless arrested by treatment.

2. *Simple Ulcer*.—The second form, described by Cruveilhier, includes:

(*a*) The *acute round ulcer*, which is most frequently found in women, often in chlorotic young women, and which is apt to be complicated by profuse hemorrhage and by perforation.

(*b*) The *chronic form*, irregular in outline, associated with thickening of the edges, and frequently found in men—according to Seymour Taylor in the proportion of 72 per cent. in males to 28 per cent. in females. This form is one which gives rise to the greater number of complications with which the surgeon has to deal.

As the result of an analysis of a large number of cases Fenwick[39] states that chronic gastric ulcer is solitary in 87, and acute ulcer in 46, per cent. When multiple ulcers exist, they may be only two in number or may be almost uncountable.

While the acute round ulcer varies from the size of a split pea to that of a florin, it is usually seen from the size of a three-penny piece to that of a sixpence; but chronic ulcers may attain almost any size, from ¼ inch up to 6 or 8 inches in diameter.

Duodenal frequently coexist with gastric ulcers. Out of 231 operations for ulcer by the Mayo brothers 158 were for gastric, 60 for duodenal, and 14 for duodenal and gastric ulcers together. Thus, out of the 231 ulcers the duodenum was involved 74 times, 55 times in men and 19 times in women, and nearly all the ulcers were indurated or chronic.[40]

An analysis of 1015 cases by Fenwick[41] shows the situation of gastric ulcers to be at the pylorus in 15.6 per cent.; lesser curvature, 36 per cent.; posterior surface, 25 per cent.; cardia, 7.9 per cent.; great curvature, 4.14 per cent.; anterior surface, 8 per cent.; fundus, 3.3 per cent.

An analysis of the site of acute and chronic ulcers shows considerable difference between the two varieties:

	Acute ulcers (39).	Chronic ulcers (70).
Pyloric zone	13 (33.3 per cent.).	53 (75.7 per cent.).
Middle zone	14 (36 per cent.).	7 (10 per cent.).
Cardiac zone	12 (30 per cent.).	10 (14 per cent.).
Posterior surface	10 (36 per cent.).	46 (73 per cent.).
Anterior surface	5 (18 per cent.).	7 (11 per cent.).
Lesser curvature	23 (59 per cent.).	10 (16 per cent.).

Of the numerous theories advanced to explain the occurrence of ulcer of the stomach, the one that seems to me the most probable is that gastric ulcers are usually septic in origin, oral sepsis being responsible for a large number of the cases, hence the greater frequency of the disease in the poorer classes, who give very little attention to the teeth. Mild sepsis leads to gastritis and to hyperchlorhydria, which in its turn provokes and keeps up ulceration.

A well-recognized accompaniment of hyperchlorhydria is spasm of the pylorus, which by obstructing the outlet leads to acute dilatation of the stomach and so to tension. A patient with gastric ulcer is, therefore, at any time liable to perforation, as the tension in the stom-

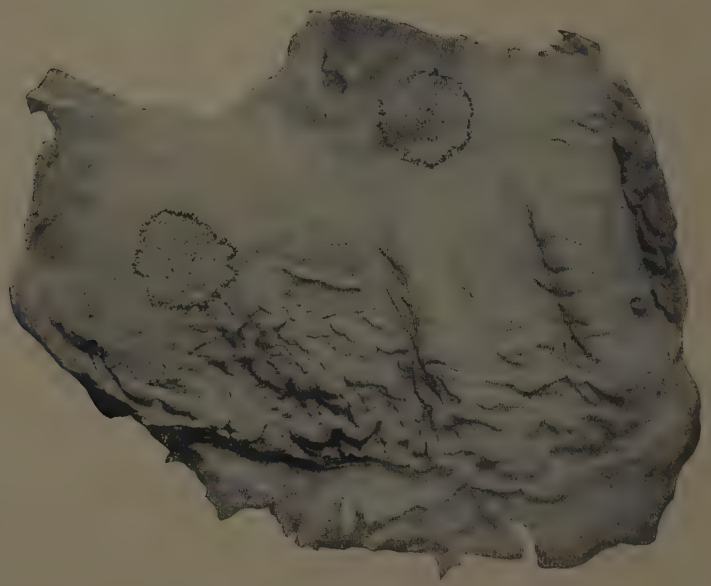

FIG. 435.—ACUTE ROUND ULCERS AND EROSIONS IN THE STOMACH OF A WOMAN AGED TWENTY, DEATH FROM PERFORATION IN FORTY HOURS.
(No. 2395*a*, Royal College of Surgeons' Museum.)

ach may lead to necrosis of the part already diseased and the digestion of the necrosed patch may lead to perforation of the stomach wall.

The *acute ulcer* is round or oval and has a punched-out appearance, the margins of the ulcer not being infiltrated to a marked extent, the base, though smooth, usually showing no evidence of granulations. The general shape of the ulcer is conic, with the base toward the interior of the stomach.

On the other hand, the *chronic ulcer* is irregular in shape and may assume very large proportions. The margins are hard and irregular and the base is much thickened and composed of cicatricial tissue. While the simple round ulcer may reach to the peritoneum without showing any evidence on the serous surface, the peritoneum over a chronic ulcer is usually thickened and may be adherent to the contiguous viscera.

Pathologic reports show that gastric ulcers are not quite equally common among men and women. For instance, Welch gives 40 per

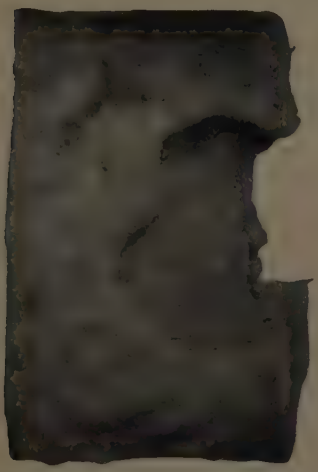

FIG. 436.—CHRONIC ULCER OF POSTERIOR WALL OF STOMACH ERODING PANCREAS. (No. 2399, Royal College of Surgeons' Museum.)

FIG. 437.—CHRONIC ULCER OF STOMACH SHOWING CHARACTERISTIC PUCKERING AND CONTRACTION THE RESULT OF HEALING. (No. 2402*a*, Royal College of Surgeons' Museum.)

cent. in men and 60 per cent. in women; and of 2031 cases collected by Fenwick, 1227 occurred in women to 804 in men. But if one were to judge from clinical experience alone it would appear that ulceration of the stomach occurs three times more frequently in women than in men, as women, especially in the third decade, are more liable to suffer from acute ulcers, while chronic ulcers are frequently found after the third decade both in men and women.

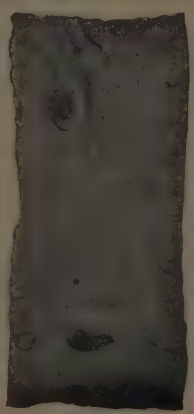

FIG. 438.—MULTIPLE ROUND ULCERS. (No. 2400, Royal College of Surgeons' Museum.)

Prognosis.—The profession as a whole has been apt to underestimate the grave mortality of gastric ulcer, even in the face of such statistics as have been given by Debove and Remond, which are accepted and quoted by Einhorn. Out of 100 cases, 50 resulted in perfect cure, 13 died of perforation or peritonitis, 5 from hematemesis, 20 from phthisis, 5 from inanition, and 5 from other complications.

Leube has said that one-half or three-fourths of all cases of gastric ulcer will be cured by four or five weeks of medical treatment, but if not cured in that time they will not be cured by medical treatment alone; in this view I thoroughly agree.

More recent statistics made at the suggestion of Mansell Moullin by Bulstrode, who analyzed all the cases admitted into the London Hospital for gastric ulcer from 1897 to 1902. They were 500 in number,

98 men and 402 women. Out of this number, no less than 48 (nearly 10 per cent.) died from peritonitis; 13 (or 2.5 per cent.) from hematemesis; and 28 (5.5 per cent.) from other causes. The total number of deaths was 89, or approximately 18 per cent., taking all the cases together. Had all the slighter ones been left out and only those reckoned in which the gravity of the symptoms suggested the possibility of operation being advisable, the rate of mortality, bad as it is, would have been far higher.

The actual rate of mortality, however, is not the only one to be considered; 32 per cent. of the cases of gastric ulcer admitted to the London Hospital were discharged as relieved or cured. Now it would be exceedingly interesting to ascertain how many were really cured; that is to say, left the hospital perfectly well without suffering pain or inconvenience when taking ordinary diet, and, what is especially important, remained well. Some idea can, however, be formed by ascertaining the number of patients admitted into the hospital with gastric ulcer who had already been treated for and cured of similar attacks. Bulstrode has done this, and has calculated that out of the 500 cases no less than 211 (42 per cent.) had suffered in this way previously. In 116 there had been only one previous attack; in 41 there had been two; in 15, three; and in 39, four or more. In other words, gastric ulcer recurs or relapses in at least two-fifths of the cases which are apparently cured.

Bad, however, as this sounds, it is not yet the worst. These figures do not include any of the cases admitted suffering from what may be called the sequelæ and complications of gastric ulcer. They do not take into account the cases admitted for pyloric stenosis (estimated at 10 per cent.), hour-glass contraction, gastric dilatation, chronic dyspepsia, constant vomiting, perigastric adhesions, cardiac stenosis, and those numerous other disorders caused by the cicatrization of ulcers healed long since. Nor do they take into account those cases in which carcinoma has developed at the site of the old ulcer, which Haaser estimates at quite 6 per cent. When allowance has been made for all these cases, which certainly cannot be described as cured, it must be admitted that the proportion of patients suffering from gastric ulcer of sufficient severity to require treatment in hospital, which are discharged as cured in the full sense of the term, in the sense in which a surgeon would use it after an operation, is not nearly so high as is generally imagined.

In further proof, Paterson[42] collected a series of consecutive cases of gastric ulcer, and with the assistance of Rhodes endeavored to ascertain their after-histories. The series comprises 153 patients, of whom 6 died in hospital and 147 were discharged as "cured." Out of the 147 patients, 72 have been traced: 40 were found to have definite signs of gastric ulcer; 5 have been subsequently operated on for hematemesis, constant vomiting, for vomiting and hematemesis, and hour-glass stomach; 1 patient died one year later in another hospital and at the necropsy an ulcus carcinomatosum was discovered. Of the remain-

ing patients 12 have at the present time no signs of gastric ulcer; 5 patients are probably "not cured," and 2 others are "probably cured." So that out of 72 patients who left the hospital apparently cured, only 10 are at the present time free from symptoms of gastric ulcer.

To avoid any possible exaggeration the 5 "probably not cured" patients are included among the "cured." Even so, 64 per cent. of the cases which have been traced have been uncured by medical treatment. Looking at the figures in the most favorable light, at least 31 per cent. of the patients discharged as cured have relapsed, while if the condition of the untraced patients be as unsatisfactory as is that of those who have been traced—and there is no reason to suppose that it would be better—the proportion of relapses would be more than double this figure. Although 19 of the patients are classified as cured, the use of the term is relative, not absolute, and implies only that at the present time these patients are free from symptoms of gastric ulcer. Only 7 out of the 19 patients have remained free from any symptoms of gastric ulcer since they left hospital. Of the 75 patients unable to be traced, it is noted that 2 of them had been in hospital twice before and 10 of them once, so that of the untraced patients 11—*i. e.*, 14 per cent.—were the subjects of relapsing ulcer. Considering that this series does not include those patients admitted with perforated gastric ulcer, or those admitted with pyloric stenosis, or other sequelæ of gastric ulcer, one may conclude that, so far as hospital patients are concerned, between one-half and two-thirds of the serious cases relapse and that the proportion of real cures is under 25 per cent.

Gastric ulcer in private practise presents a different picture, as private patients, amid more favorable surroundings, more readily bear the necessary restriction of their diet and relapse is much less common. Consequently, operation is not usually required in this class of patients for the treatment of an existing ulcer, but rather for those cases in which, owing to neglect to commence treatment early, cicatrization of the ulcer has produced pyloric stenosis, gastric adhesions, or hour-glass contraction.

We may thus, on ample evidence, accept the fact that at least 50 per cent. of all cases of ulcer of the stomach treated medically ultimately succumb to the disease or to one or other of its complications.

How does surgical treatment compare with this? As surgeons, we only see the worst cases that have failed to yield to medical treatment; yet, arguing from my own experience alone in over 300 operations of various kinds for ulcer of the stomach and its sequelæ which had failed to yield to medical treatment, the total mortality of all operations in this worst class of ulcers, including hour-glass contraction and hemorrhage, but excluding perforation, has only been 3 per cent.; but, as shown later, the immediate risk of posterior gastro-enterostomy in my private practise in these cases amounted only to 1.7 per cent. and the cases completely relieved of all symptoms were over 90 per cent.,—a proportion that will be still better as experience increases.

Symptoms.—The special symptoms of ulcer of the stomach are pain,

vomiting, and hematemesis, but I have seen and operated on quite a number of cases in which pain had not formed a prominent symptom, in which hematemesis had been entirely absent, and vomiting had not come on until stenosis of the pylorus had produced dilatation.

The pain is usually referred to the epigastrium, whence it may radiate in various directions, though generally it is toward the left subscapular region. Food usually increases the pain and the time of onset after food is frequently indicative of the site of the ulcer. If the ulcer be near the cardia or along the lesser curvature the pain usually comes on immediately or within half an hour of food. If it be at or near the pylorus it may be delayed from an hour to two or three hours after eating, whereas if it be in the duodenum it may not occur until four hours after a meal, and in that case it is almost invariably relieved by food. As digestion is frequently delayed in the evening, pain of this character has a habit of wakening patients at midnight or later, so that in chronic cases a glass of milk will be regularly placed by the bedside in order to relieve the expected discomfort.

Epigastric tenderness is usually well marked and is frequently associated with rigidity of the recti; it may be strictly localized or widely diffused. A special tender point is often found in the back, a little to the left of the spine, opposite the ninth and tenth dorsal vertebræ.

Vomiting is a frequent symptom of ulcer of the stomach and, as a rule, it gives immediate relief by removing the food and the acid contents of the stomach. In some cases vomiting is a very serious symptom, leading to profound inanition and utter inability to take or retain food; but in others vomiting is not a marked feature of the disease. Although gastrorrhagia is present at one time or another in the greater number of cases, it does not always show itself as hematemesis or melena, and may only be rendered evident by a microscopic examination of the alvine excretions. This symptom is more fully considered on p. 870.

The following are the complications that may be found in connection with gastric ulcers:

1. Acute perforation of the stomach and general peritonitis. 2. hematemesis and melena. 3. Cicatricial stenosis of the pylorus. 4. Hour-glass stomach. 5. Tumor of the stomach or pylorus of inflammatory origin. 6. Dilatation of the stomach due to obstruction. 7. Fistula between the stomach or pylorus and adjoining organs or on the surface of the body. 8. Spasm of the pylorus with gastrosuccorrhea, producing intermittent stenosis (Reichmann's disease). 9. Persistent vomiting. 10. Local peritonitis or perigastritis, ending in adhesions. 11. Local peritonitis, ending in suppuration and a localized abscess. 12. Subphrenic abscess. 13. Abscess of the liver, pancreas, or spleen. 14. Atonic motor deficiency. 15. Severe gastralgia. 16. Tetany. 17. Stenosis of the cardiac orifice. 18. Acute or chronic pancreatitis. 19. Profound anemia resembling the pernicious form. 20. Pressure on, or stricture of, the bile-ducts, with jaundice. 21. Catarrh of the

gall-bladder from adhesions, producing attacks like those of cholelithiasis. 22. Great loss of flesh and strength, ending in phthisis. 23. Cancer secondary to ulcer, ulcus carcinomatosum. The more prominent of these complications are considered under separate chapters.

Differential Diagnosis.—It may be ordinarily concluded that epigastric pain related to food, vomiting, and localized epigastric tenderness constitute a combination of symptoms pointing to ulcer, but that if hematemesis is superadded, the existence of ulcer is almost certain.

The more acute the symptoms and the shorter the time between their onset and the seeking of advice are points in favor of the diagnosis of ulcer; and if the symptoms do not subside after a few days in bed with care in diet, ulcer is probably present.

Examination of the Stomach Contents.—The presence of free HCl, especially if in excess, in the vomit or in the gastric lavage after a test-meal, is confirmatory evidence of ulcer; whereas the absence of free HCl and the presence of lactic acid are presumptive evidence in favor of malignant disease. In anemic dyspepsia and in septic gastritis free HCl is frequently diminished, whereas in nervous gastralgia it may be increased.

As the results of the observations of several authors the following conclusions may be drawn:

Free nuclei of epithelial cells and of leukocytes (Jaworski's kernel) mean the presence of free HCl.

Epithelial cells and entire leukocytes mean the absence of HCl. Large clumps of leukocytes with blood-cells point to an ulcerating surface.

Sarcinæ go hand in hand with the presence of HCl and stagnation of stomach contents.

Oppler-Boas bacilli in large numbers go with the presence of lactic acid and stagnation of stomach contents.

Thus, stagnating contents with presence of HCl, sarcinæ, yeasts, and free nuclei point to pyloric stenosis of a non-malignant character.

Stagnating contents, with absence of HCl and presence of lactic acid with Oppler-Boas bacilli, point to malignant pyloric stenosis.

A tumor may be present in some cases of chronic ulcer. It is important, therefore, in such cases to obtain an accurate analysis of the stomach contents, as the presence of an excess of free HCl would suggest that the tumor is not cancer. In the differential diagnosis between ulcer of the duodenum and ulcer of the stomach, the occurrence of the former more frequently in men and after middle age, the presence of melena often with hematemesis, the "hunger pain" occurring from three to four hours after meals, and the tenderness to the right of the middle line will usually afford sufficient evidence of duodenal ulcer.

Latent ulcers are not uncommon. I have, on several occasions, operated for perforating ulcer where there had been no premonitory symptoms, and Savariaud gives the proportion of latent ulcers as 20 per cent. of all cases of gastric ulcer.

In cases of perforative peritonitis it is worth remembering that the history of paroxysmal pain is seldom absent when the perforation is due to ulcer of the stomach, it being usually under the left scapula when the cardiac end or the body of the stomach is involved, and sometimes under the right scapula when the ulcer is at the pylorus or in the duodenum.

Surgical Treatment.—Although one cannot fall in with the views of certain extremists, who draw a parallel between the treatment of hernia and that of ordinary gastric ulcer and propose that as hernia is treated radically with success, so ought gastric ulcer always to be treated surgically; for, as has been shown in discussing the prognosis, a considerable proportion, probably 40 to 50 per cent., recover under medical treatment. If, however, gastric ulcer is not cured after medical treatment has been thoroughly carried out, or if after apparent cure it relapses, then surgical treatment should be resorted to.

To Rydygier[43] belongs the credit of having performed the first operation for the cure of a gastric ulcer. In the year 1881 he resected a large ulcer from the posterior wall of the stomach, the patient being completely cured; and in 1882 Czerny successfully performed a similar operation. The field of surgical activity in gastric surgery was extended in 1893, when Doyen[44] performed gastrojejunostomy for the treatment of ulcer.

Talma[45] had independently also come to the same conclusion as Doyen, that spasm of the pylorus was the chief factor in maintaining hyperchlorhydria, which prevented the healing of gastric ulcers.

At the present time the surgical treatment of gastric ulcer consists either in excising the ulcer or in the performance of gastro-enterostomy, and for my own part I feel that even if it be desirable to excise the ulcer, gastrojejunostomy ought at the same time to be performed.

As a rule acute ulcer, apart from the complications of perforation or bleeding, does not call for surgical treatment; it is only when the ulcer relapses or becomes chronic that operation is called for. Moreover, gastric ulcer, among private patients, whose surroundings are much more favorable and who are capable of resting and following out a systematic dietary, is more amenable to medical and general treatment than when it occurs among the poor, who are impatient of restriction of diet and are unable to take a sufficiently prolonged rest. It is thus evident that surgical treatment is called for more often in hospital than in private practise.

When, some years ago, the mortality of any surgical proceeding was great, physicians naturally advised their patients to persevere with medical treatment rather than to submit to an operation which was attended with great risk; but now that the mortality after the operation of gastro-enterostomy has been reduced to about 1 per cent. in simple cases in skilled hands, and when even excision of the ulcer if thought desirable can be performed with very small risk; and further, when it is fully realized that gastrojejunostomy does not interfere with normal nutrition or with the metabolic processes of the body

and that after its performance patients may live in perfect health for many years; doubtless all gastric ulcers that relapse or produce serious symptoms will be treated surgically at a much earlier stage than has hitherto been the custom.

There seems to be no reason why patients should be allowed to suffer month after month and year after year until they have become worn out and emaciated to an extreme degree, when they can be treated surgically with a risk to life of only 1 or 2 per cent. and a probability of cure in 90 per cent. or more of all cases operated on.

I feel sure, however, that the performance of surgical operations in cases of neurasthenia associated with vague gastric symptoms unaccompanied by definite clinical or mechanical signs of ulcer or of stasis is, as a rule, unjustifiable and can only lead to the discredit of useful surgical procedures in that other distressing class of cases where organic disease is present.

The surgical treatment of ulcer apart from complications is first to complete the diagnosis by opening the abdomen.

The history of the time of onset of pain after food will be some guide as to the site of the ulcer; for instance, if the pain has occurred immediately after food, the ulcer will probably be near the cardiac orifice or on the lesser curvature; if two to three hours after, it will be at the pylorus, and if four hours after meals and relieved by food, the ulcer will generally be found in the duodenum.

Should the area of ulceration appear to be limited and freely accessible, excision of the ulcer may be worth considering. If the ulceration is at the pylorus, especially if it be associated with thickening resembling a neoplasm and if the pylorus be free from adhesions, the removal of the ulcerated pylorus may be advisable, for it has to be borne in mind that chronic ulcer has in many cases been the site of origin of cancer. I have excised the pylorus or otherwise removed the ulcerated area 9 times for chronic ulcer, all the patients having recovered from the operation. The ultimate results are no less interesting than instructive; 6 of the patients are now living and in good health from one to seven years after operation; 1 cannot be traced; 1 relapsed three months after pylorectomy, and in 1 case, after two years of health, fresh ulceration with perforation occurred.

If, however, the pylorus is fixed by adhesions and its removal would be difficult, or if an ulcer of the stomach be adherent to the liver or pancreas, it is much wiser to be content with the operation of gastro-enterostomy, which yields such satisfactory results, both immediate and remote.

Even after the excision of an ulcer, gastro-enterostomy should be performed in order to set the stomach at rest and secure the healing of other ulcers that so frequently coexist.

Rydygier prefers excision because he believes that the scar of an ulcer may become the site of carcinoma. While the development of carcinoma on ulcer cannot be doubted, it is not yet clearly proved that carcinoma does develop on the scar of a soundly healed ulcer.

There can be little doubt that excision is a more serious operation than gastrojejunostomy, especially if the excision of the ulcer necessitates the removal of the pylorus. Czerny's statistics extend over a long period and have been analyzed by Petersen and Machol.[46] These comprise 4 resections of the pylorus with 2 deaths, a mortality of 50 per cent.; and 7 excisions of ulcers with 3 deaths, a mortality of 42 per cent.

Though the mortality from excision need not be greater than that from gastro-enterostomy (as shown by my own cases), it is probably less efficient, as ulcers may be multiple and the patient may still remain unrelieved; whereas gastro-enterostomy, by diminishing the acidity of the gastric juice and preventing tension, relieves the condition which prevents healing of the ulcers. I, therefore, prefer, even where I have excised an ulcer, at the same time to perform gastro-enterostomy.

Mansell Moullin[47] is an advocate of excision of ulcer where it is practicable, but he has recorded 2 cases where it has not proved satisfactory, and I have also recorded 2 cases that relapsed.

With few exceptions the operation of choice in chronic ulcer of the stomach is gastro-enterostomy, which, by affording a free outlet from the stomach, prevents stasis of food, relieves hyperchlorhydria, and secures physiologic rest to the whole organ. Moreover, it is an undoubted fact that gastric ulcers are generally multiple and that not infrequently duodenal ulcers coexist, the removal of one ulcer would, therefore, not be likely to cure the disease, whereas a gastro-enterostomy will prove curative to both gastric and duodenal ulcers, whether one or many be present.

For duodenal ulcer I do not think any other operative procedure than gastro-enterostomy is either necessary or advisable unless there be perforation, and even in case of perforation, if the patient is in a fit condition to bear it, a gastro-enterostomy ought to be done at the same time that the perforation is repaired.

I prefer the posterior operation, both for gastric and duodenal ulcers, making the opening into the stomach close to the lower border and the opening into the jejunum as near to the duodenojejunal junction as practicable. I never see regurgitant vomiting and, as a rule, recovery is as smooth as after a simple ovariotomy.

The after-results of gastro-enterostomy in ulcer of the stomach, pylorus, and duodenum are really very remarkable: the pain vanishes, food can be taken freely, anemia disappears, and the patient, as a rule, rapidly puts on flesh, so that I have seen several cases double their weight within the first few months after operation.

Statistics.—The statistics of gastro-enterostomy for ulcer cannot be accurately estimated by merely collecting a large series of cases from the records of all the general hospitals in which perhaps only a few operations are performed by each member of the staff and with very varying results, but a true estimate may be obtained by a consideration of the results of individual operators who have accurately recorded and followed up the after-progress of their cases.

Nor do I think it quite fair in estimating the mortality to put the cases of ulcer complicated by hemorrhage or hour-glass contraction into separate lists, as it might open the way to misrepresentation of the actual results if the simple uncomplicated cases are placed in a separate category.

The following statistics include the results of gastro-enterostomy for ulcer and its complications—hemorrhage and hour-glass contraction—following the plan employed in the excellent reports of St. Mary's Hospital, Rochester, Minnesota.

W. J. Mayo reported[50] having performed 307 gastrojejunostomies for non-malignant disease with a mortality of 6 per cent., but in the last 81 operations of the series there had been only 1 death; and in his report for 1905 out of 109 gastrojejunostomies performed for ulcer or the results of ulcer of the stomach and duodenum, only 1 patient died.

At the British Medical Association meeting at Leicester in 1905, Moynihan[49] gave the result of his experience up to date: The cases included 171 gastrojejunostomies for chronic ulcer with 2 deaths; 27 cases in which hemorrhage was a prominent symptom with 4 deaths, and 8 cases of hour-glass stomach in which gastrojejunostomy had been performed with 3 deaths, thus making 206 cases of ulcer with its complications of hemorrhage and hour-glass contraction in which gastrojejunostomy had been performed with 9 deaths, a mortality of 4.3 per cent.

The following is my own personal experience: Including every instance, whether simple or malignant, in which I have performed the operation of posterior gastro-enterostomy, either in hospital or in private practise, there have been 209 cases, of which 202 recovered from operation, thus giving a mortality of 3.3 per cent.

In giving the statistics of the treatment by posterior gastro-enterostomy of ulcer of the stomach and duodenum, including the serious complications of hemorrhage and hour-glass contraction, it is necessary not only to show the immediate risks but also the ultimate results.

As the after-histories are almost impossible to obtain with any degree of accuracy from the class of patients seen in hospital, I have preferred to base my observations on my private cases, in which the after-histories have been kindly furnished by the medical colleagues with whom I was associated.

Of the 112 posterior gastro-enterostomies that I have performed in my private practise for ulcer or its complications, including hemorrhage and hour-glass contraction, 110 have recovered, thus giving a mortality of 1.7 per cent.

Out of the 110 recoveries, 96 are in good health now, at periods varying from within a year up to five years after operation; 2 were alive and well three years subsequent to operation, but no reply has been received as to their present condition; 2 were alive and well some time after operation, but no word has been received of them later; 1 lived in good health for two and a half years and when traveling in

Italy died of acute pneumonia; 1 remained in perfect health for three years, but has lately had some vomiting; 1 lived in good health for three and a half years after operation and then developed cancer in the abdomen; 1 lived two and a quarter years and died of cancer of the stomach; 1 had perfect health for a year, when a tumor at the pylorus developed, but no further operation was permitted and she died two months later; 1 had improved health for two and a half years, when she had hematemesis and died shortly after an attack; 1 was well for two years, when she had recurrence of vomiting; a further operation was performed, but the old gastro-enterostomy opening was found to be perfectly patent, and though the patient is living, her condition is not satisfactory; 1 has never been well since operation two years ago and has now developed a tumor in the colon; 1 has since died of pernicious anemia; 1 has been relieved, but still suffers at times from pain and flatulence after food.

Thus it will be seen that 101 out of 110 posterior gastro-enterostomies for ulcer or its complications performed in private practise resulted in cure.

PERFORATION OF GASTRIC ULCER.

This complication of gastric ulcer is one of the most serious accidents that can happen, since unless treated surgically it is fatal in 95 per cent. of cases.

The symptoms of perforation of gastric ulcer may be acute, subacute, or chronic. *Acute* when the perforation takes place suddenly direct into the peritoneal cavity, which is immediately flooded with the contents of the stomach. *Subacute* when perforation occurs suddenly, but the stomach being empty and the opening small the symptoms are less intense, as the peritoneum is not flooded with the stomach contents and the opening becomes partly or wholly occluded by adhesions of plastic lymph or by a plug of omentum. In this class of cases there are frequently premonitory symptoms caused by local peritonitis and pouring out of lymph on the peritoneum when the ulcer reaches the surface and before perforation has actually occurred. In this subacute form recovery sometimes occurs under medical treatment alone, as I have proved on several occasions in which I have operated at some time subsequent to perforation, and found conditions pointing to the accuracy of the original diagnosis.

Chronic, in which perforation occurs into the peritoneum protected by a barrier of adhesions due to previous inflammation. The escape of the gastric contents is, therefore, limited and the inflammation is localized, usually leading to a perigastric abscess, possibly subphrenic.

Chronic perforation is apt to occur more frequently through the posterior wall, whereas acute and subacute perforation take place more frequently through the anterior wall of the stomach.

Frequency of Perforation in Gastric Ulcer.—This is variously estimated: Fenwick gives it as 28.5 per cent.; Habershon, 18 per cent.; Brinton, 13 to 15 per cent.; Lebert, 12 per cent.; Welch, 6.6 per cent.

of all cases of gastric ulcer. In 20 per cent. of the recorded cases the perforations were multiple, and in a very large proportion of perforating ulcers there are also other ulcers in the stomach, though not necessarily perforating.

Age and Sex.—A case of perforated ulcer of the stomach in an infant aged forty-five hours, causing death, was reported by Bisset.[51] At the post mortem a typic acute ulcer with clean cut edges was found to have perforated the posterior wall of the stomach near the lesser curvature, about ½ inch from the cardiac opening. Fenwick refers to 18 collected cases of ulcer in childhood; but perforation at this early age is very rare. Perforation, though commoner in the third decade, may occur at any time up to extreme old age.

FIG. 439.—A CHRONIC ULCER SHOWING SMALL PERFORATION AND ANOTHER THAT HAS LED TO CICATRICIAL CONTRACTION OF PYLORUS.
(No. 2398, Royal College of Surgeons' Museum.)

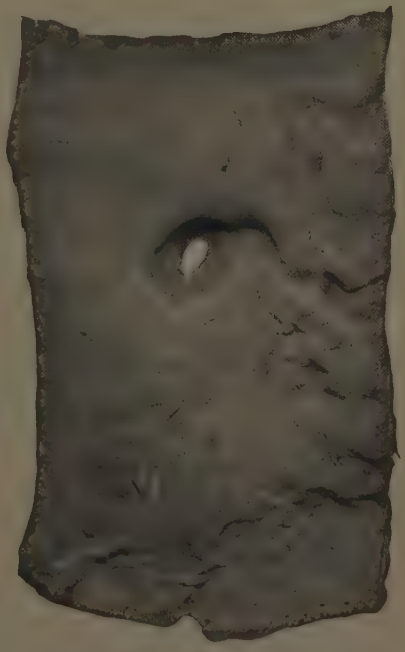

FIG. 440.—A PERFORATING ACUTE ROUND ULCER CAUSING DEATH IN A WOMAN TWENTY-TWO YEARS OF AGE.
This is the common condition. There is a *chronic* ulcer with an *acute* perforation. (No. 2396, Royal College of Surgeons' Museum.)

Although five-sixths of all cases of perforation of gastric ulcer occur in women, the greater number in young women under twenty-five, yet allowing for the greater frequency of ulcer in women we find that perforation is relatively more frequent in men, especially in men over the age of forty.

Site of Perforation.—Although ulcers occur more frequently on the posterior wall, perforations are more frequent on the anterior. Pariser and Linder state that of 200 ulcers, 190 will be on the posterior wall, and of these 4 will perforate, whereas, of 10 on the anterior wall,

8½ will perforate. Acute ulcers perforate more frequently near the cardiac extremity; chronic ulcers near the pylorus.

Fig. 441, modified from Mr. Sargent's paper,[52] shows the site of perforation in 77 cases, the black dots representing 66 perforations on the anterior surface, the crosses representing 11 perforations on the posterior surface.

The size of the perforation may vary from a point scarcely perceptible to one the size of a shilling or even larger. A small opening is characteristic of the subacute; a larger, of the acute cases. The variation in the size of the opening is important, for a small perforation when the stomach is empty will allow little of the stomach contents to escape and it may be occluded and lead only to a local inflammation, whereas, a large perforation, especially if occurring with a full stomach, may lead to a flooding of the peritoneum with food and irritating fluid, rendering recovery without operation hopeless.

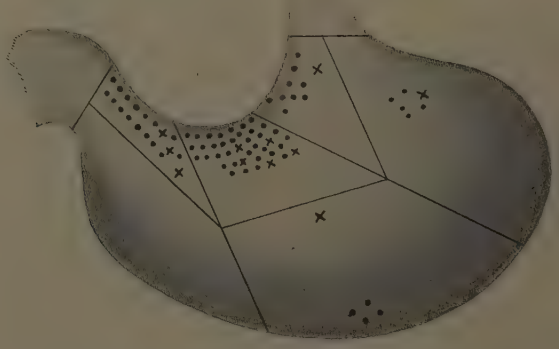

FIG. 441.—PATHOLOGIC PERFORATIONS OF THE STOMACH.
Anterior surface represented by black dots = 66. Posterior surface represented by crosses = 11.

Symptoms.—A sudden sharp abdominal pain accompanied by shock is usually an initial symptom in perforation. Almost immediately the expression of the face changes to one of anxiety and great distress; the extremities become cold and clammy and the face blanched; the respirations are usually shallow and quick, and the pulse rapid and almost imperceptible at the wrist; vomiting may occur or may be absent, but if present the efforts of vomiting increase the distress. Hematemesis may or may not occur. In some cases where the onset is subacute the symptoms are less marked and shock may be absent, though in rare cases the shock may be so great as to lead to sudden death. As a rule the patient rallies and the initial symptoms of shock pass off to a certain extent. There is then a great complaint of thirst which cannot be satisfied and the urine is scanty and high colored.

On examining the abdomen the recti are rigid and the whole abdomen feels like a board and does not move during respiration. At first the abdomen is retracted, but later it becomes distended with gas and fluid and, as a rule, a thrill can be obtained in the flanks and, later,

from side to side. Liver dulness is generally absent and if this is noticed immediately it has great significance; but later, when the colon is distended with gas, the absence of liver dulness is not a matter of great importance from a diagnostic point of view. General emphysema has been noticed, but is an extremely rare symptom. Perforation may come on without any premonitory warning and without any previous digestive symptoms, but usually, on strict inquiry, it will be found that the patient has suffered from indigestion for some time previously.

In subacute perforation with an empty stomach the symptoms are all less marked than in the acute, though they are of the same type. At first the signs are those of local tenderness and muscular rigidity, but at any time there may be an extension with all the symptoms described in acute perforation.

Chronic perforation will be considered under Perigastric Abscess, p. 867.

Differential Diagnosis.—Any intraperitoneal disaster may be mistaken for perforating gastric ulcer. Such cases as acute perforating duodenal ulcer, ruptured tubal gestation, acute hemorrhagic pancreatitis, acute perforative appendicitis, phlegmonous cholecystitis, or perforation of the gall-bladder have been mistaken at the beginning for perforating ulcer of the stomach, but as all these diseases require immediate surgical attention no serious harm can result from such a mistake. This cannot be said of other conditions which may resemble perforating ulcer; for instance, pneumonia with a sudden pleuritic pain, acute irritant poisoning, and acute dilatation of the stomach.

A careful history will usually enable a correct diagnosis to be made in nearly all cases, and the fact that in over 90 per cent. a previous history of gastric irritation can be obtained is of diagnostic importance. The rigidity of the abdominal muscles, especially above the umbilicus, the presence of a thrill owing to fluid in the abdomen, the immediate absence of liver dulness, and the sudden onset, especially if associated with a previous history of dyspepsia, should afford a sufficient guide; but in case of doubt a small exploratory incision 1 inch in length will enable a positive diagnosis to be made without serious additional risk.

Treatment.—Although very rarely a perforating ulcer, especially of the subacute type, may heal spontaneously, to wait in any case in which perforation has been diagnosed in the hope that it may become localized is utterly unjustifiable. If a diagnosis cannot be clearly established, but there is a strong suspicion of perforation, an exploratory incision sufficiently large to admit the finger should be made; when, if there is perforation of the stomach, inodorous gas or the fluid contents of the stomach will escape and the incision may then be extended for treatment, whereas if the exploration should prove negative no harm is done.

To Mikulicz (in 1880) belongs the credit of the first intervention in perforating gastric ulcer, though the first successful operation was performed in 1892 by Kriege. In October, 1888, I had the privilege of performing one of the earliest operations, if not the earliest, in

England; unfortunately the case was not operated on until the third day, when general peritonitis had already supervened.

Operation.—An incision of about 4 inches is made in or near the middle line above the umbilicus, and as soon as the abdomen is opened there is usually an escape of gas and fluid. A rapid survey of the whole of the stomach is then made, beginning at the cardiac end. If no perforation is found on the anterior surface the great omentum immediately below the greater curvature is torn open through a part where it is thin, and through the slit two fingers can be passed to explore the posterior surface; or if thought desirable the transverse colon and great omentum can be raised and a slit made through the mesocolon, which gives more complete exposure and enables the whole of the lesser peritoneal cavity to be examined. When found, the perforation must be closed. It is not necessary to excise the ulcer. The edges may be first brought together by chromic catgut sutures and if the perforation is small a purse-string peritoneal suture of silk or celluloid thread can be applied; but if the aperture be large, a continuous Lembert suture, reinforced by several interrupted sutures, must be applied outside the marginal stitch. In some cases where it is impracticable to bring the margins of the perforation accurately together a piece of omentum may be brought up and stitched over the site of the ulcer.

After the perforation has been closed the peritoneum may be cleansed in one of two ways, either by means of free lavage with normal saline solution at a temperature of from 105° to 110° F. This can be done with very little disturbance, and if the whole of the peritoneum is soiled by extravasation it is a most efficient method of treatment, as it helps to combat shock; a glass drainage-tube can then be passed into Douglas' pouch through a small incision above the pubes, which the tube accurately fills. If, after the abdomen is closed, the patient is put into the semi-erect posture, fluid gravitates to the pelvis and will be drained away through the tube. If, however, the soiling of the peritoneum is limited to the area around the stomach or to the right kidney pouch, as occurs in early perforation near the pylorus or in the first part of the duodenum, to wash out the abdomen is to distribute the infective material. In such cases it is better to wipe away the offending fluid. Too much time should not be spent in cleansing, nor should the stomach or intestines be handled roughly. During the time that the intestinal coils are being freed of particles of food or infected lymph the adjoining coils should be kept covered with warm moist towels.

As perforation in 20 per cent. of the recorded cases has occurred at two or more points, it is of the utmost importance that the surgeon should carefully examine the stomach to see that a second perforation has not escaped his notice. The necessity of drainage is not always easy to determine. Undoubtedly many cases are drained that would do quite well without it. This was clearly proved by a series of cases published by my friends Littlewood[60] and Edward Ward.[61]

Arguing from my own practise, whenever I think it necessary to adopt lavage of the peritoneum, I always think it advisable to insert

a suprapubic drain and to prop up the patient so as to make the pelvis dependent. It may, however, be borne in mind that an apparently unaltered peritoneum is capable of taking up a large amount of effused fluid and may, therefore, not require drainage, whereas a damaged serous sac that is dull and has lost its polish cannot absorb so well and should be drained.

If general septic peritonitis has developed, the lavage with hot normal saline solution should be very thorough and the abdomen should not be closed on distended intestines, as it is quite easy to bring a coil of intestine out of the wound, to make a small puncture in it, and by means of Cawardine's tube thoroughly to empty the distended part and rapidly pass the adjoining coils between the fingers so as to force the gas and intestinal fluids to the tube. The point of incision in the intestine may then be rapidly closed by a marginal and a purse-string suture.

Gastro-enterostomy in Perforating Gastric Ulcer.—Seeing that ulcers of the stomach are multiple in a very large proportion of cases and that after the closure of one or more perforations others may occur within the next few days, or should they not then occur, the ulceration may continue and cause trouble at a later date, I have a strong feeling that if the patient is in a condition to bear it gastro-jejunostomy should be performed after the closure of the ulcer.

The procedure was carried out for the first time by Braun, in 1893,[53] on a patient with a perforated gastric ulcer, in which the friability of the surrounding tissues was such that an approximation of its edges was impossible. He closed the gap with an omental graft and performed gastro-enterostomy, the patient making a good recovery.

In some cases, however, where the patients are very ill the additional time involved in the performance of gastro-enterostomy may be sufficient to turn the scale. No absolute rule can, therefore, be formulated.

In view of the suggested desirability of performing gastro-enterostomy after closure of the ulcer, the statistics given by Crisp English[54] are of importance. He was able to trace 15 out of 22 patients who had recovered after operation. Of these 11 had had no return of symptoms, while 4 had suffered from gastric trouble subsequently, which might or might not have been due to gastric ulcer. Barker[55] mentioned that 1 out of 5 of his cases had relapsed and threatened a second perforation. In 1 of my own cases a gastrojejunostomy was required six months after an operation for perforated pyloric ulcer. Paterson, in his *Hunterian Lectures*,[56] ascertained the subsequent history of 35 out of 54 patients who had recovered from perforated gastric ulcer. Of these 17 suffered subsequently from gastric trouble; 1 died from a second perforation twenty-one months after the first perforation; 2 subsequently required gastrojejunostomy, while at the time of his lecture 9 had definite symptoms of gastric ulcer and 5 had symptoms of dyspepsia.

The cases in which gastro-enterostomy had been done at the same time as the ulcer was closed were too few in number from which to

draw conclusions. Ward's cases[61] illustrate the value of gastrojejunostomy in perforation.

The arguments in favor of the performance of gastro-enterostomy are: 1. That other ulcers present at the time of perforation will be cured by the operation. 2. That if a second ulcer is on the point of perforation such perforation will probably be prevented, as tension of the stomach walls will be avoided. 3. That after gastro-enterostomy more secure healing of the sutured ulcer is likely to occur, and there will be less likelihood of the stitches giving way. 4. It diminishes the risk of hematemesis occurring after operation. 5. It enables saline aperients to be given shortly after operation and so secures more efficient drainage of the peritoneal cavity (Paterson). 6. It permits earlier feeding than would otherwise be the case. 7. If the ulcer is at the pylorus it prevents the danger of stenosis.

On all these accounts, therefore, it is important that when the patient's condition will permit of it a gastro-enterostomy should be performed at the same time that the perforating gastric ulcer is closed.

Prognosis Based on Statistics.—The prognosis in perforating ulcer depends chiefly on the time elapsing between the perforation and operation, but it is also influenced by the condition of the stomach, whether full or empty at the time of perforation, as well as on the size and number of the perforations.

Among the latest statistics on the operative treatment of perforating gastric ulcer are those of Crisp English,[57] on a series of 60 consecutive cases, in which the mortality was 48 per cent.; and a series of 112 consecutive cases collected by Paterson. Of these 58 died, yielding a mortality of just under 52 per cent. The same author collected a series of 58 operations performed in twelve of the London hospitals during 1904. Of these 28 died, giving a mortality of 48 per cent. Littlewood tells me that he has personally operated on 31 cases of acute perforation with 17 recoveries, and of these 7 were treated without drainage. In 29 of the cases the ulcers were incised and the opening closed by a continuous suture. All the fatal cases had perforated more than twenty-four hours before operation.

The appended table[58] shows what an important element time is in the prognosis:

	Total cases.	Recovered.	Died.	Percentage of deaths.
Under 12 hours	49	35	14	28.5
From 12 to 24 hours	33	12	21	63.6
From 24 to 36 "	16	2	14	87.5
From 36 to 48 "	2	..	2	100.0
Over 48 hours "	33	16	17	51.5

The best example of the excellent results of early operation with which I am acquainted were reported by Sinclair Kirk[59]—11 cases with 11 recoveries—8 were done within five hours after perforation; 1 seven, 1 ten, and 1 twenty hours after perforation.

One must not lose sight of the fact that while early operation is of

the utmost importance, it is also equally important that the operation ought to be a thorough and complete one.

In a paper read before the Royal Medical and Chirurgical Society, May 22, 1906, Moynihan reported 24 operations for perforation, 16 from ulcer of the stomach, and 8 ulcer of the duodenum, with 15 recoveries, giving a mortality of 37.5 per cent.

PERIGASTRIC ABSCESS INCLUDING SUBPHRENIC ABSCESS FROM CHRONIC PERFORATION OF THE STOMACH.

By far the greater number of abscesses around the stomach result from perforative ulcer. In the majority the ulcerative process is chronic, which permits the formation of adhesions; but subacute perforation of a limited character and imperfect drainage after operation for acute perforation may both lead to the same results.

Perigastric abscess may bear any relation to the stomach, and like abscess elsewhere may vary in acuteness or chronicity. Such an abscess may slowly develop in either the hypochondrium or in the epigastrium and make its way to the surface and burst, or it may rupture into one of the adjoining hollow viscera or through the diaphragm into the pleural or pericardial cavities. One of the commonest occurrences is for the abscess to make its way upward beneath the diaphragm, when it forms a subphrenic abscess. This is any collection of pus or pus and gas, which as a whole or in part intervenes between the diaphragm and the structures normally in contact with it.

In 179 cases of subphrenic abscess collected by Maydl, 20 per cent. were due to perforating ulcers of the stomach and duodenum.

Subphrenic abscess from other causes is dealt with elsewhere in this work (Vol. I., p. 267), hence it is only necessary to consider it briefly here.

The symptoms of chronic perforation of the stomach are at first a history, often long continued, of gastric ulcer followed by an extension of the inflammation and increased local signs in the upper abdomen. Tenderness in the epigastrium or in either hypochondrium will usually be noticed and there is frequently the development of a tumor which gradually extends. Although at times the pain may be sudden and sharp, it is frequently difficult to state the time at which perforation occurred, the process being a gradual one; or there may be a sudden severe pain, pleuritic in character, accompanied by faintness, and presenting the aspect of an acute thoracic condition. Pleurisy, pericarditis, or empyema may develop later. Vomiting may occur from the gastric irritation and distressing attacks of coughing from the thoracic extension. Rapid loss of flesh takes place with great debility and night-sweats. If the abscess bursts into the lung there will be profuse purulent expectoration. Pressure on the heart and lungs may lead to great dyspnea.

In the diagnosis of pleuritic effusion from subphrenic abscess the upper limit of dulness is not so sharply defined and breath sounds may often be heard below the level of the dulness. If a deep inspira-

tion be taken, the line at which the breath sounds and vocal resonance are heard and at which vocal fremitus is felt is distinctly lowered. The movements of the chest are not so much impaired in subphrenic abscess as in pleurisy with effusion. Along with the thoracic will also be found abdominal signs and symptoms.

In a case of subphrenic abscess from chronic perforation of the stomach I elicited a sign which I have not seen described and which I think may be present and afford help in many such cases. On placing a stethoscope over the eighth intercostal space, which region was dull on percussion, and on placing a coin over the stomach and percussing it with another coin, the sound was distinctly conveyed through the

FIG. 442.—POSTERIOR PERIGASTRIC ABSCESS.

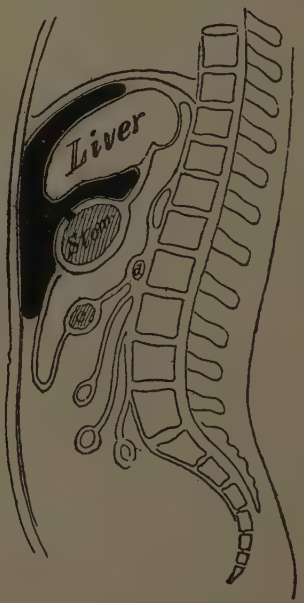

FIG. 443.—ANTERIOR PERIGASTRIC ABSCESS.

whole of the abscess cavity and through the stethoscope to the ear. The diagnosis was confirmed by operation.

As gas is usually present in the abscess, a tympanitic note will be heard over the upper part of the abscess cavity quite different in character from that heard over the lung above it At the upper part of the abdomen metallic tinkling can often be heard and a succussion splash may be elicited. Over the area of hyperresonance the "bruit d'airain" may be heard. If the perforation has occurred into the lesser peritoneal sac, though the symptoms are well marked, the physical signs will be less distinct. The abscess may burst into the lung or into the pericardium before being recognized, or into the stomach and be vomited. In some cases the pus may burst into the retroperitoneal tissue and burrow extensively. For instance, I have opened a perigastric abscess in the left groin and another in the left iliac region.

Treatment.—The only treatment that can be counted upon in subphrenic abscess is incision with free drainage. According to Lang, who collected 176 cases, the percentage of recoveries after operation is 47.9, but without operation only 12.3. The incision must, as a rule, be made over the most prominent part of the abscess, whether that

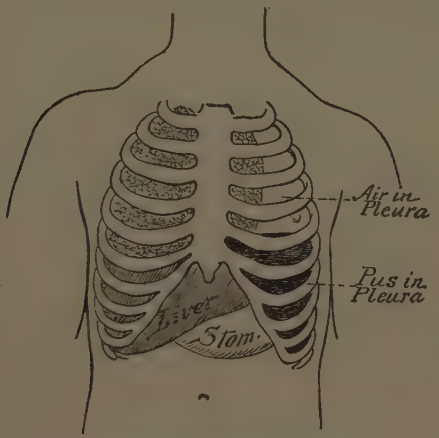

FIG. 444.—PYOPNEUMOTHORAX.

be in the abdomen or in the thorax. In the latter case it may involve removing a portion of a rib in order to secure efficient drainage. If the pleura is opened it is better if possible to stitch together the two layers of pleura before opening the abscess cavity.

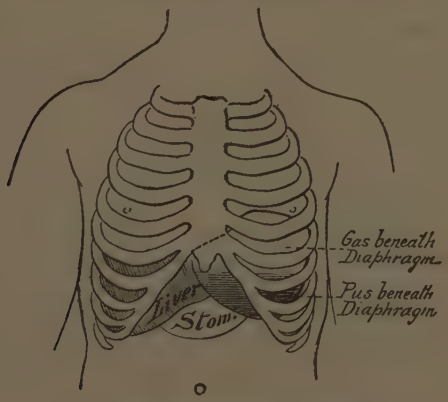

FIG. 445.—SUBPHRENIC ABSCESS.

Although attention must first be paid to the drainage of the abscess cavity, the cause must not be lost sight of and will probably demand treatment as soon as the patient is in a fit state to bear an abdominal section. In a case under my care recently, in which after-symptoms pointing to pyloric and duodenal ulcer extending over twenty years,

a right-sided subdiaphragmatic abscess developed, which was successfully drained through the eighth intercostal space, and a month later, as the stomach symptoms were persisting, a gastro-enterostomy was performed with complete success.

The following figures show the course the pus is likely to take in perforation of the anterior and of the posterior wall of the stomach and show the different relations of the fluid and gas in pyopneumothorax and subphrenic abscess.

HEMORRHAGE.

Hemorrhage from the stomach or duodenum is usually known as *hematemesis* when the blood is vomited as perceptible blood, or *melena* when it is passed by stool in such quantity as to give the motions a tarry appearance; but blood may be vomited in smaller quantity so as only to be found on microscopic examination or it may be altered by digestion and vomited as coffee-ground material; it may also be passed by stool in small quantities, only to be demonstrated by chemical tests or on examination by the microscope.

It is only since the advances in gastric surgery that the treatment of gastric hemorrhage has become a surgical question.

While the causes of hemorrhage from the stomach and duodenum are numerous, the only one I propose to consider in this chapter is that due to simple ulcer in its various forms.

Hemorrhage occurs in a greater or less degree in from 50 to 80 per cent. of all cases of gastric ulcer, and, according to various authors, is fatal in from 3 to 11 per cent.

The bleeding may be arterial, venous, or capillary, and, curiously, capillary hemorrhage may be so free as to render it difficult to say that some large vessel has not given way, yet after death a careful examination may fail to discover any gross vascular lesion. Although capillary hemorrhage may supervene on other conditions, such as congested portal circulation, enlargement of the spleen, and general engorgement of the venous system, yet there are two special conditions in which the bleeding may be so free as to raise the question of surgical treatment; these are vicarious hematemesis at the menstrual period and postoperative hematemesis, in both of which general experience has established the desirability of medical rather than surgical treatment.

Venous hemorrhage, if from perforation of one of the large trunks, such as the coronary, splenic, or portal, may cause speedy death, but owing to the diminished pressure in the veins and the more languid circulation a rapidly fatal result is less likely than in arterial bleeding.

Arterial bleeding is mostly responsible for the serious and fatal hematemesis due to gastric ulcer. The bleeding may be from the small arterioles which radiate between the peptic glands, from the trunks along the curvatures, the coronary being the most frequently affected, or from extrinsic arteries, the splenic alone being responsible, according to Brinton, for 55 per cent. of the deaths in fatal hematemesis.

The pancreaticoduodenal and right gastro-epiploic are the arteries chiefly affected in pyloric and duodenal ulcers.

The peculiarly fatal nature of hemorrhages from medium-sized arteries depends on the fact that an ulcer makes a lateral opening into the vessel which prevents natural hemastasis by retraction and contraction of the artery. The whole force of the heart is then exerted on the clot which tends to form during the syncope that usually occurs when a large quantity of blood is suddenly poured out.

The interval between the first onset of bleeding and death is of great importance surgically and is well shown by Savariaud.[64]

In the present state of our knowledge it is impossible to diagnose the size of the vessel perforated, either from the amount of blood lost or the length of survival. A probable diagnosis of the site of bleeding may be arrived at in hematemesis from ulcer by a careful study of the previous history, especially with regard to the site of the pain, the time of onset after food, and the influence of posture, as well as by the way in which the pain radiates. The situation of the tender spot, the presence or absence of tumor, and of dilatation or contraction of the stomach also afford assistance. As will be seen later, the diagnosis of the site of the ulcer and, therefore, presumably of the bleeding is of great importance from a surgical point of view and will influence both the advice given as to treatment and the method of procedure when the abdomen is opened.

It seems convenient to classify the subject under two headings, as from the point of view of treatment there exist considerable differences of opinion as to the advisability of surgical treatment in one of these classes:

(1) The acute, often very severe, attacks of gastrorrhagia that occur in young anemic women suddenly without any warning and often without any symptoms, pointing to ulcer of the stomach; attacks that at the time appear very alarming, but which usually cease spontaneously and do not tend to recur. Hood pointed out the significance of these cases in 1892.[70] This form of bleeding may cause death, yet on post-mortem examination the stomach lesions at first sight seem altogether inadequate to explain the serious nature of the attack.

Until recently, and even yet by some authors, an ulcerative lesion of the stomach not readily recognizable by the naked eye, though obvious on examination by a lens, was not acknowledged to be true ulceration; and in such cases the bleeding was not recognized as being due to ulcer. F. J. Smith[62] has described a number of these cases in which small ulcers, no larger than a pin's head, not spreading superficially and discoverable only on close scrutiny, were found to lead directly into a blood-vessel, and in several of the cases described by him fatal hemorrhage had occurred. The two varieties of superficial erosions described by Dieulafoy also give rise to terrible hemorrhages that may prove rapidly fatal.

In 1870, Murchison[63] reported 2 cases of fatal hemorrhage from minute ulcers which had perforated a small artery in the wall of the

stomach. In 1872, Chiari also observed a similar case. The 2 cases operated on by me, and reported in my work on *The Stomach*,[69] come under this class of simple ulceration.

(2) In the second variety the bleeding is associated with a definite ulcer of the stomach or duodenum. It may occur in the following forms:

(*a*) An acute fulminating hemorrhage, ending rapidly in death. (*b*) Severe bleeding which, though arrested temporarily, tends to recur in a few hours or a few days, and which, after one or more relapses, may prove fatal. (*c*) Slight frequently recurring hemorrhages, tinging the vomit or only found on careful examination of the feces, yet leading to profound bloodlessness that may at first be mistaken for pernicious anemia.

In the variety of acute fulminating hemorrhage, ending fatally either suddenly or with great rapidity, surgical treatment is impracticable and has hitherto never been attempted.

A brief description of several cases of recurrent hemorrhage out of many on which I have operated will be found in my work on *The Surgery of the Stomach*.[69]

Treatment.—From the fact that medical and general treatment is successful in arresting acute hematemesis in 93 to 96 per cent. of cases, and that it is difficult in the present state of our knowledge to say at first that the bleeding is not from capillaries or small arterioles, it necessarily follows that medical treatment should always have a fair trial in every case of acute hematemesis. The very fact that medical treatment is so often successful in cases of apparently alarming hematemesis goes to show that capillary oozing or bleeding from arterioles is much more common and accounts for many more cases of gastric hemorrhage than has hitherto been supposed. But while thoroughly believing this, we must also not close our eyes to the experience we have in general surgery of bleeding from medium-sized arteries, such as the radial or ulnar, which we know would rapidly cause death if only perforated on one side and surrounded by warm compresses, a condition that practically applies in all cases of hematemesis where the larger vessels are eroded. If, therefore, medical treatment and rest properly carried out are not successful in arresting the bleeding in a few hours, or if after being arrested it recurs, we should be driven to the conclusion that a large vessel is perforated, and if a surgeon has not been previously asked to see the case, a surgical consultation ought surely to be held with a view to considering operation and immediate arrest of bleeding by direct treatment if the patient is in a fit condition to bear it.

An analysis of the table of M. Savariaud of 54 cases, showing the prolongation of life in various fatal cases of hematemesis, demonstrates that in 10 out of 54 cases—that is, in 18.5 per cent.—death occurs so quickly that there is barely time to consider the question of surgical treatment, and that in 17 out of the 54 cases (31.4 per cent.) death occurs within from twenty-four to thirty-six hours after the first appearance of hemorrhage. Now, although at present these cases are

often allowed to die without operation, yet if the bleeding were from a radial or tibial or any accessible artery they would all be saved by the simple operation of direct ligature of the bleeding vessel. The difference is, however, not merely only one of accessibility, but also one of diagnosis, for if we are able to diagnose capillary hemorrhage the case will be generally one for medical treatment alone, but if the time arrives when we can diagnose with great probability arterial hemorrhage from a large vessel, the case will, I believe, be considered one for surgical treatment.

Where there have been distinct signs of gastric ulcer preceding the hemorrhage and where a sudden hematemesis has occurred with great loss of bood accompanied by syncope, a large vessel will usually be found to be the source of the bleeding. In all such cases not speedily yielding to medical and general means in the future, surgical treatment will probably be carefully considered and in some it will be adopted, for there can be formulated no absolute rule that will apply to every case. Each must be considered on its merits. The present condition of the patient, the previous history, the surroundings, the possibility of skilled surgery, and of good nursing and other circumstances will all help in the decision.

At present, with the exception of Dieulafoy, who advocates operation during the first bleeding if as much as half a liter of blood is lost, all other surgeons who have written on the subject agree that general means ought to be relied on during and after a first attack, as in from 93 to 95 per cent. of cases such treatment succeeds. Until our means of diagnosis as to the size of the vessel is rendered more reliable we must assent to this rule. But after a second bleeding I have no hesitation in advising operation as soon as the condition of the patient will permit, for experience tells us that further hemorrhages are almost certain to occur unless preventive measures be adopted.

The first suggestion of surgical intervention in hematemesis was made by Rydygier in 1882. To Mikulicz, however, on February 13, 1887,[65] belongs the credit of having been the first to operate for hemorrhage from a gastric ulcer, though Roux, of Lausanne, was the first to perform a successful operation.

Conclusions.—To put the matter succinctly I would say:

(1) In a case of acute hematemesis from ulcer or erosion, when the onset of bleeding is sudden and the previous history of ulcer is absent, medical and general means should be very thoroughly tried. If the bleeding ceases as the result of rest and general treatment there will be no cause to interfere surgically, though the treatment should be carried out thoroughly and persistently until the ulcer has healed.

(2) In case of recurrence of bleeding or should the bleeding persist despite treatment, surgical measures are called for.

(3) In case of bleeding from a chronic ulcer, whether the bleeding be slight or severe, surgical treatment is demanded, not only for the arrest of hemorrhage, but also for the curative treatment of the ulcer itself.

(4) As the risk during the quiescent interval is less than if the opera-

tion is undertaken while the bleeding is continuing, it is desirable, if possible, to secure arrest of the hemorrhage even in chronic ulcer before undertaking operation; but if the hemorrhage is persisting the surgeon is not justified in waiting until the patient is reduced to such a condition that it is too late to operate.

The **surgical treatment of hematemesis** may be direct or indirect. By the *direct method* is meant: (*a*) Excision of the ulcer or of the ulcer-bearing area. (*b*) Arrest of hemorrhage by ligature of the bleeding vessel, by cauterization of the ulcer, or by ligature of the mucous membrane *en masse*.

By the *indirect method* gastro-enterostomy is meant. As a rule, any operation for hematemesis must be at first exploratory and when the condition of the stomach is ascertained the question of direct or indirect treatment can be decided.

In all the early cases of operation for hemorrhage from the stomach the direct method was adopted, as it had not then been realized that by securing physiologic and physical rest to the stomach by gastro-enterostomy, not only could bleeding, as a rule, be arrested, but the condition of ulceration giving rise to it could be cured.

Mansell Moullin still advocates the direct method by ligature *en masse* of the bleeding area or by excision of the ulcer,[66] and he urges in support of his view the fact that there have been cases recorded in which hemorrhage has persisted or recurred after gastro-enterostomy.

An extensive personal experience and the consideration of a large number of cases operated on by others, whose work I have had the opportunity of seeing or studying, has convinced me that gastro-enterostomy is a most efficient means of treating hemorrhage from the stomach; and it is only under very exceptional circumstances that I should now think it worth while to open the stomach and treat the ulcer directly. But even should I deem direct treatment of the bleeding point necessary, I should also think it equally desirable to perform a gastrojejunostomy in order to secure rest to the stomach and to the ulcer, so as at the same time to stop the bleeding and cure the condition giving rise to it.

Gastrojejunostomy possesses the advantage that it is applicable to both acute and chronic hemorrhage, that it avoids the necessity of a prolonged search through a gastrotomy opening, that it is quickly performed, and, not least, that it involves little or no shock and is attended with a very small mortality.

A collection of a large number of cases of the direct treatment of the bleeding point not only shows a very heavy mortality, but also a want of relief to the condition giving rise to the bleeding in a large proportion of cases.

Technic of the Direct Operation for Gastrorrhagia.—On account of the fear of exciting fresh hemorrhage it is undesirable to wash out the stomach before operating on a bleeding ulcer, and as the patient is usually anemic and will, therefore, bear shock badly, it is desirable to have him enveloped in cotton-wool or otherwise kept warm on a heated

table, and to give him a subcutaneous injection of strychnin before operation. If it be unnecessary to infuse saline fluid before the operation, an assistant should be ready to perform it while the abdominal operation is being proceeded with, should it be called for. After the abdomen is opened the stomach should be carefully examined, as very frequently a puckering of the surface or thickening of the coats will be noticed at the site of the ulcer, or a difference in color may sometimes indicate its site. Should the operator be fortunately able to find these indications much time may be saved. But if no indications of this sort be obtainable and it is decided to adopt direct treatment, the stomach must be drawn well forward and opened either by a vertical incision,

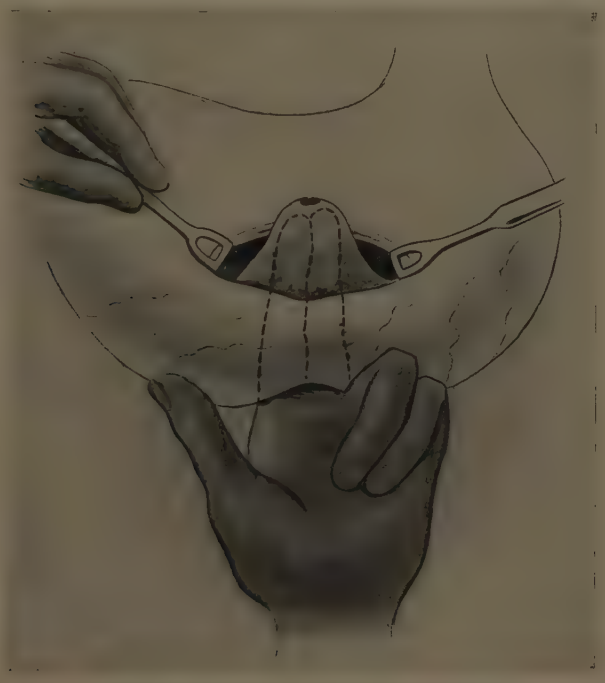

FIG. 446.—METHOD OF EXPOSURE OF ULCER.

which produces less hemorrhage, or by an incision in the long axis of the stomach, which affords a much better view of the interior. In order to avoid soiling the peritoneum the area of operation should be surrounded by sterilized gauze. The edges of the stomach should then be held open by forceps, one above and below and one at each end.

The interior of the stomach must now be systematically examined: first, the anterior and posterior surfaces, then the upper and lower curvatures, and lastly, the pyloric and cardiac orifices, all of which can be done by the naked eye or with the aid of an electric cystoscope or a reflected light. If the posterior wall of the stomach cannot be efficiently examined a slit may be made in the omentum and two fingers

pushed through it and employed to invaginate the posterior wall. If no ulcer can be found on the wall of the stomach the duodenum should be explored, not only by the finger but by invagination. If no ulcer be found anywhere and the bleeding proves to be capillary or from small undiscoverable ulcers, gastro-enterostomy should be performed. But if an ulcer be discovered and it be possible to excise it, that operation may be done. After excision of the ulcer and ligature of the bleeding vessels the edges of the small wound should be brought together by sutures. Should excision of the ulcer involve the peritoneal coat it is desirable to apply Lembert's sutures, and if it be on the posterior wall the operation may present some, though not insuperable, difficulty.

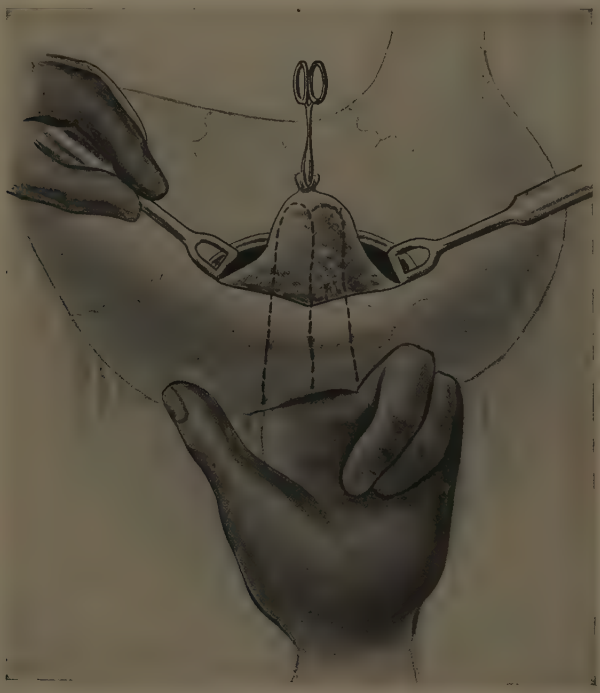

FIG. 447.—LIGATION OF BLEEDING POINT.

Should the ulcer be discovered in some region where excision is impracticable—for instance, near the cardiac end—the application of the cautery, as adopted by Mikulicz in his first operation in 1887, may be employed. This seems to have answered well in several cases, and where death occurred afterward it was not from a recurrence of the bleeding. But in a case of this kind gastro-enterostomy is also advisable in order to set the stomach at rest. If any superficial points of bleeding be discovered they may be caught up by forceps and ligatured, but this is more easily said than done, as the mucous membrane is very friable and a ligature, if drawn at all tightly, tends to cut its way through; moreover, forceps easily tear the mucous membrane and may produce

a larger bleeding area. The method of ligaturing *en masse* may be employed if the ulcer is small; it proved serviceable in 2 of my cases, and it is easy of application when the ulcer can be reached. It has been tested by experiments on animals by Eisendrath, but it has been shown to endanger perforation if the serous coat be taken up, except when supported by external sutures. Ligature of the main arteries of the stomach was suggested theoretically by Savariaud when no bleeding ulcer could be discovered; it does not, however, commend itself as being safe or likely to be efficient.

Should the bleeding be from an ulcer at the pylorus, pyloroplasty may be performed, the ulcer being excised and the edges of the gap left by the excised ulcer as well as the edges of the incision being united, so that the line of sutures shall be transverse to the axis of the pylorus. I would not, however, advise pyloroplasty when there is active ulceration of the pylorus unless the ulcer can be completely excised, for in cases of this kind I have had disappointment owing to contraction in healing. In 1 case the patient made a good recovery from the operation, but subsequently suffered from stenosis, for which a further operation had to be done. In a second case recovery took place and the patient regained his lost weight, but subsequently a tumor of the pylorus developed which was thought to be cancer and for which I had to perform pylorectomy; and in the third case perforation subsequently occurred. I think, therefore, that in case of ulcer of the pylorus, where a clean excision of the ulcer cannot be done, it is better at once to perform pylorectomy if removal of the ulcerated area is thought desirable. Wherever the pylorus is adherent, as in my experience it is in so many cases of ulcer, I prefer gastro-enterostomy; but if the pylorus be extensively ulcerated and free from adhesions, pylorectomy can be almost as quickly performed as gastro-enterostomy.

After arresting the bleeding the wound in the stomach must be closed by a double continuous suture; one of catgut taking up the margins of the opening, the outer of silk or cellulose thread taking up the serous coat. The abdominal wound can then be closed in the usual way.

HOUR-GLASS STOMACH.

Etiology.—Hour-glass stomach is a deformity in which the stomach is divided into two separate cavities. This term was adopted long ago when the disease was always thought to be congenital, and before it was recognized that the stomach might be divided into two, three, or four cavities; but the name is sufficiently distinctive to hold its own in medical literature.

Causes.—Hour-glass stomach owes its origin to definite organic disease—chronic gastric ulcer, cancer, or perigastritis—but the greater number of cases are caused by cicatricial contraction due to ulcer. Doubtless very rarely the condition may be congenital, just as congenital narrowing may be found at the pylorus, in the intestine, or in the rectum. As yet, however, in an experience of considerably over 1000 operations on the upper abdomen, in which the stomach could be seen and examined,

over 500 of which have been on the stomach itself, I have not met with a single instance in which I could say that the case was one of congenital hour-glass contraction. Nevertheless, it is only fair to say that many authorities have stated that congenital hour-glass stomach is common (*e. g.*, Fenwick).

Perigastric adhesions may cause narrowing of the stomach in one of two ways, either by a band passing across the stomach and constricting it or by an adhesion tying up the stomach, so that when the patient is erect two sacs are formed by the sagging of the lower wall of the stomach. The food that is passed onward then has to be forced upward from the first cavity into the second, though when the patient is lying down the same difficulty is not experienced.

An ulcer may lead to hour-glass contraction in two ways: In one form a chronic ulcer of the anterior abdominal wall perforates and fixes the stomach to the parietes and this, with subsequent cicatricial contraction, leads to considerable deformity; or an ulcer may extend transversely to the long axis of the stomach, and by its contraction lead to a stenosis which may be so extreme as only to permit the passage of a small probe. This I have seen on several occasions.

Syphilitic disease of the stomach, either in the form of ulcer or gumma, may result in contraction leading to hour-glass deformity. Cancer may produce hour-glass contraction when it extends transversely to the axis of the stomach, and in some cases I have operated on the growth had formed an annular stricture leading to extreme stenosis in the center of the stomach. In some of the specimens cancer has clearly originated on a chronic ulcer.

In hour-glass stomach the stricture may occur at any part, though it is generally near the middle or at the junction of the distal third with the proximal two-thirds of the viscus; but it may also occur in the dome of the stomach or the stricture may be just beyond the cardiac orifice. The stricture may be quite a narrow one or may be elongated so that the first sac is connected with the second sac by a long stricture of 1 inch or even more. The greater curvature is generally drawn up toward the ulcer, but in 1 case recorded by Schwarz, and another under the care of the late Mr. Jessop, the lesser curvature was puckered down to the greater curvature.

Although ordinarily there are two cavities in hour-glass stomach, there may be three or even four cavities, and it is not uncommon to find an associated stenosis of the pylorus. The accompanying figures (Fig. 448) demonstrate some of the various deformities the stomach may assume in this condition.

Symptoms.—The symptoms for a time depend entirely on the cause, whether that be ulcer, cancer, or perigastritis. Ultimately, when the deformity has developed, the signs are more or less distinct. The common symptoms are those of dilated stomach supervening upon chronic ulcer, and many cases have been sent to me with that diagnosis. Some of the specific signs of hour-glass stomach are, however, so distinct as to leave no doubt:

(1) On washing out the stomach the fluid introduced seems to disappear and is not returned through the tube, the explanation being that it passes into a second cavity. (2) When the stomach is washed out until the fluid returns clear, and lavage is performed again after a few minutes, dirty fluid is returned, due to the reflux from the unwashed second cavity. (3) Sometimes after the first cavity is emptied by lavage, a splashing sound can still be found in the second cavity. (4) On passing fluid into the proximal cavity the distention may sometimes be seen to empty itself and to cause distention of the second cavity. (5) When the cavities contain fluid and air, by alternately compressing each cavity the contents can be made to pass from one into the other, when a gurgling sound is heard near the center of the stomach. (6) On distending the stomach with CO_2 a sulcus may occasionally be seen between the two cavities of the hour-glass stomach.

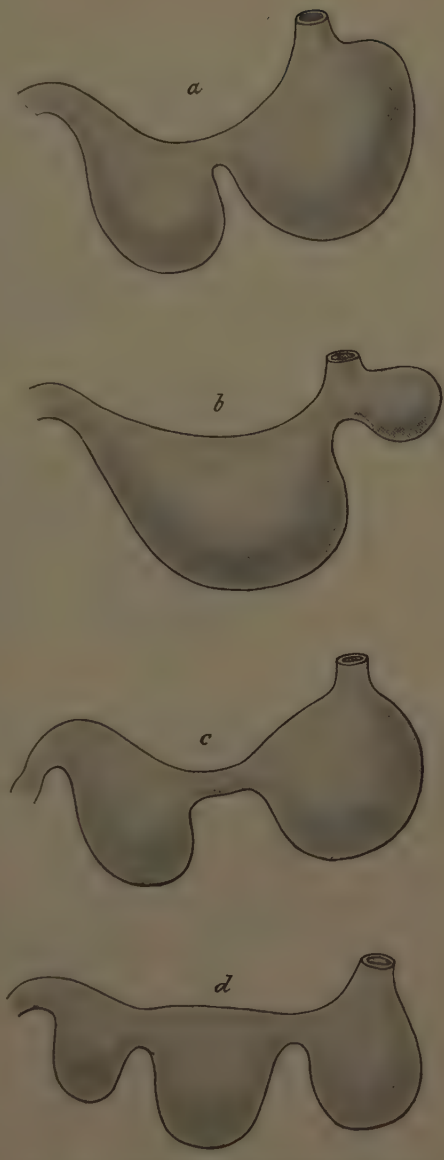

FIG. 448.—VARIETIES OF HOUR-GLASS STOMACH.

a, Ordinary form of hour-glass stomach in later stage, the pyloric pouch being also dilated; *b*, case of the author's, in which a small pouch of the dome was separated from the remainder of the stomach by a constriction; *c*, case of the author's, in which the stricture formed a narrow tube connecting the two cavities; *d*, case of the author's, in which there were three cavities.

Differential Diagnosis.—(*a*) A cancerous stricture of the second part of the duodenum with dilatation of the duodenum beyond the pylorus may cause the appearance of two separate sacs, the constriction being in the middle. I operated on 1 case of this kind which had been previously diagnosed as hour-glass stomach.

(*b*) If the stricture be near the cardiac orifice regurgitation of food may occur simulating esophageal stricture, but a correct diagnosis may easily be made in this case by the passage of a bougie, for if an

esophageal bougie passes for over 16 inches the obstruction is in the stomach.

(*c*) It has happened that an hour-glass stomach with dilatation of the distal cavity has been mistaken for simple dilatation due to pyloric stenosis, and that a futile operation has been performed by connecting the distal sac to the jejunum. A careful examination of the exposed stomach will always avoid such a mistake.

Treatment.—Only surgical treatment is of service. The objects of the operation are to overcome the obstruction and to secure physiologic rest for the healing of the ulcer, which is by far the most frequent cause of this deformity. Out of 26 cases operated on by myself and 19 reported by my colleague, Moynihan, 37 were the result of ulcer or perigastritis.

The operations available are: (1) Gastroplasty, (2) gastro-enterostomy, (3) gastrolysis, (4) gastrogastrostomy, (5) excision of the ulcerated area or partial gastrectomy, (6) divulsion of the stricture, and (7) jejunostomy.

Before any curative procedure is adopted it is essential that a complete examination of the stomach should be made, otherwise a stenosis near the cardiac end may be missed, as in at least 2 recorded cases. The choice of operation will depend on the condition found. If adhesions be the cause of the constriction, their treatment by gastrolysis will be necessary, though at the same time other treatment will usually be called for, as in 1 of my cases, where a gastro-enterostomy was required and in another where gastroplasty was performed.

If the constriction be near the center of the stomach and free from active ulceration, and if the pylorus is patent, a gastroplasty alone will be required. In my own 10 cases of simple gastroplasty, all the patients recovered and 6 are known to be in good health at the present time, from two to five years later; one was known to be well a year later, but no further record was obtainable; one required gastro-enterostomy two years later for ulcer of the pylorus, the gastroplasty being then quite sound; one was well for four years, had recurrence of ulceration, and died of hematemesis, and one writes to say that after five years she has had some pain, but does not need medical attendance.

If the pylorus be also stenosed, a gastro-enterostomy must be associated with the gastroplasty, or it may be advisable to do a gastro-gastrostomy together with a gastro-enterostomy or, better, a gastro-enterostomy with two openings into the jejunum, one from either sac; this operation was suggested by Weir and Foote.[71] If active ulceration at the strictured part with considerable induration be present, the proximal cavity being dilated and the pylorus patent, a posterior gastro-enterostomy will answer all the indications.

In 7 cases of hour-glass stomach on which I performed posterior gastro-enterostomy, all recovered and 5 are well at the present time, two to five years after operation; 1 died of cancer of the sigmoid flexure four years later and 1 of cancer of the stomach within a year of operation.

If the induration and ulceration are forming a tumor that is doubtfully malignant, it may be wise to excise the ulcerated area.

If the pouches on each side of the constriction are dilated and the pylorus is patent, simple gastro-enterostomy into the proximal sac may be performed instead of gastroplasty, but the fact of dilatation of the distal pouch is usually an indication that it also requires drainage by the double operation.

Divulsion of the stricture or of the pylorus is not, as a rule, advisable, as it is not likely to give permanent relief.

Jejunostomy as a temporary measure is advisable if the patient is very feeble and if the stomach presents signs of very extensive disease that would require a long operation.

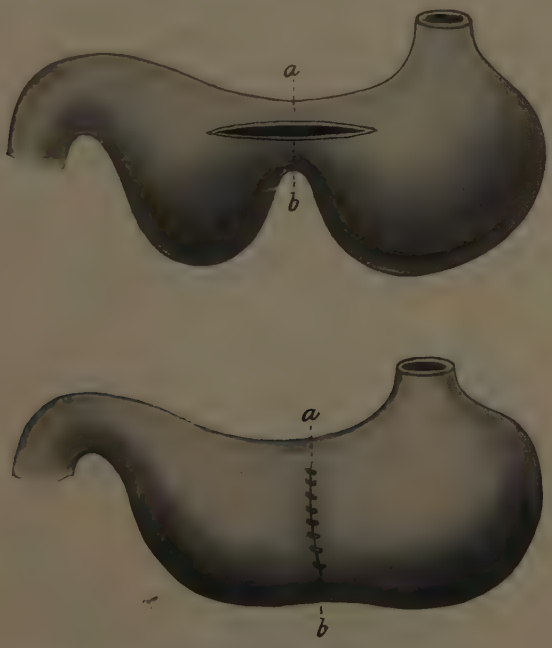

FIG. 449.—GASTROPLASTY.
Longitudinal incision through stricture stitched up transversely to the axis, so that the points *a* and *b* correspond in the two illustrations.

The Operation of Gastroplasty.—This is an adaptation to the body of the stomach of Heineke's operation for pyloric stenosis. It was performed by Bardelben in 1889, by Kruckenberg in 1892, and I believe that the operation I performed in May, 1899, was the first that had been done in Great Britain. The patient is now living and well seven years later.

Having exposed the stricture, brought the stomach to the surface, and surrounded it by sterilized gauze, an incision at least 4 inches in length is made in the longitudinal axis, the stricture being at the center of the incision. The edges are then drawn apart so as to make the longitudinal slit into a vertical one, as shown in Fig. 449. Two con-

tinuous layers of sutures are then applied, one through all the coats uniting the apposed mucous membranes, this suture being of catgut, preferably chromic gut; the outer suture which unites only the serous coat being of celluloid thread or silk.

Gastroplasty is not an ideal operation if ulceration is still continuing, as in such cases it is likely that further contraction will occur; for although the operation immediately overcomes the deformity, it does nothing to cure the ulceration which brought it about. Moreover, should the pylorus be stenosed, a not infrequent combination in hour-glass deformity, and which is usually indicated by a corresponding dilatation of the pyloric cavity, a gastroplasty is contra-indicated unless it is combined with a gastro-enterostomy. If the stricture is an elongated one, gastro-enterostomy will also be the better operation.

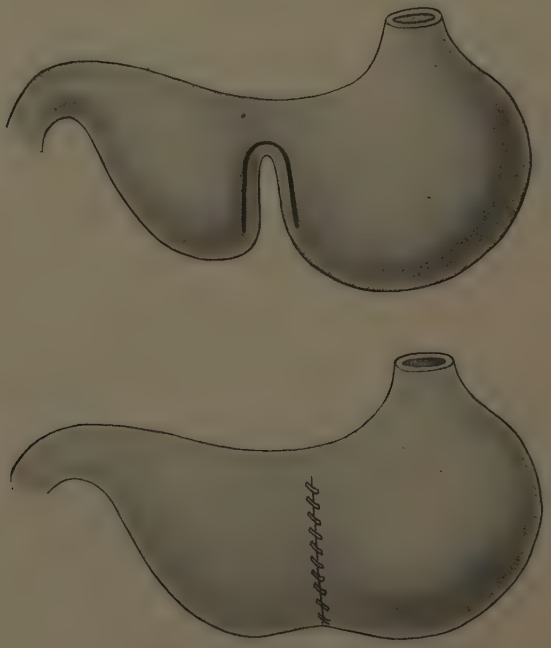

FIG. 450.—KAMMERER'S MODIFICATION OF PYLOROPLASTY.

Kammerer's[73] modification of the operation of gastroplasty, quite similar to Finney's operation, is described by him as follows: "Beginning at the lowest point of the constriction, a running suture is applied through the serous and muscular coats, bringing the vertical edges of both compartments of the stomach into close approximation along their posterior margins. An inverted U-shaped incision is now made through the entire thickness of the stomach wall, about $\frac{1}{4}$ inch to either side of the Lembert suture. The posterior wound edges are now brought together with another running suture from within, the same procedure being then applied to the anterior edges from without. The final act of the operation consists in reinforcing the anterior suture with a

running Lembert stitch and placing a few extra sutures at the lowest point of the stomach through the serous and muscular coats, where tension would naturally be greatest. The accompanying figures help to explain the original description.

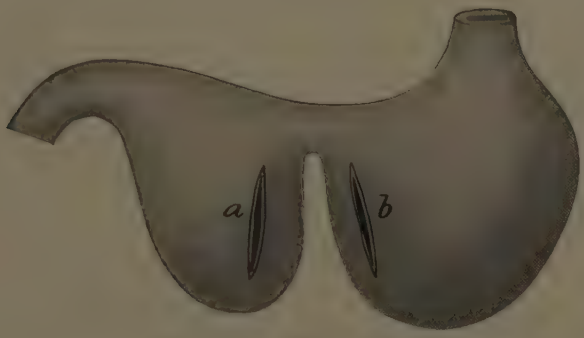

FIG. 451.—GASTROGASTROSTOMY.
The two cavities are anastomosed by joining the openings *a* and *b*.

The Operation of Gastrogastrostomy.—Gastrogastrostomy or gastro-anastomosis was first performed by Wölfler in 1894. It consists in uniting the two cavities of an hour-glass stomach so as to make the proximal cavity freely empty itself into the distal one. When the

FIG. 452.—THE SITE OF THE ULCER, THE ADHESIONS, AND THE FURROW IN THE ANTERIOR WALL OF THE STOMACH.
The dotted line shows the site of the two incisions made after the adjacent margins of the furrow were sutured together.

stomach has been drawn forward and surrounded by sterilized gauze, a stomach clamp is applied on each side of the fissure dividing the cavities. A continuous suture of celluloid thread is then applied to unite the serous margins posteriorly, the unthreaded needle being temporarily put aside. In front of this suture an incision of quite

2 inches is made into each stomach cavity and a continuous catgut suture is then applied through all the coats, so as to unite the margins of the incision and bring the mucous membrane of the two cavities into apposition; this is continued to the starting-point, when it meets the first end of the catgut suture, the two ends being tied and knotted. The serous suture, which had been previously laid aside, is now taken up and continued round to the point of starting, uniting the two serous surfaces. In order to secure a sufficiently patent opening I prefer personally to use a decalcified bone-bobbin as a splint over which to apply the sutures, but this is merely a modification of the suture operation. Fig. 452 is taken from a paper by Keen.[72] It shows the line of incision adopted in one of his cases.

This operation is sufficient when the pylorus is not strictured, but should pyloric stenosis complicate hour-glass contraction, a posterior gastro-enterostomy must be carried out at the same time.

Gastrojejunostomy for Hour-glass Stomach.—The operation of *gastro-enterostomy* is fully described on p. 888. I have found this the

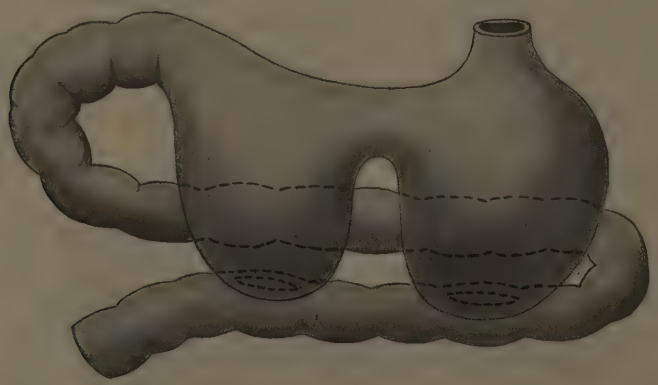

FIG. 453.—DOUBLE GASTROJEJUNOSTOMY.

most generally useful of any operation for hour-glass stomach, as it completely sets the stomach at rest and allows the ulcer or ulcers to heal. If there is a sufficiently wide opening between the proximal and distal cavities no further operation than gastro-enterostomy will be necessary, but should the stenosis between the cavities be well marked and should there be also a stricture of the pylorus, the operation must either be modified so as to give a double opening into the jejunum, as shown in Fig. 453, or it must be associated with a gastrogastrostomy, so that both cavities of the stomach may empty themselves into the jejunum. A mistake has occurred on several occasions by uniting the distal pouch of an hour-glass stomach to the jejunum, but this will not occur when a thorough examination is made of the stomach before any operation is begun.

Partial Gastrectomy for Hour-glass Stomach.—In case of cancer of the center of the stomach producing hour-glass contraction, where

the glands are not too extensively involved or the disease has not affected other organs, partial gastrectomy should be the operation of choice, and in certain cases of simple disease where there is extensive thickening forming a tumor the nature of which is doubtful, excision may be advisable. I have performed this operation on 2 cases of cancer, both of which recovered, one, a man aged sixty-two, lived for sixteen months, and the other, a middle-aged woman, lived in perfect health for over four years, when there were signs of recurrence.

Divulsion of Stricture in Hour-glass Stomach.—The operation of divulsion of stricture may occasionally prove useful when, on account of extensive adhesions or from proximity to the cardiac orifice, a more complete operation cannot be performed with safety, but it is not an

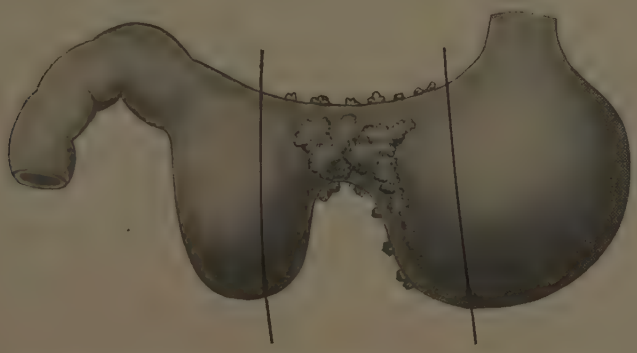

FIG. 454.—GASTRECTOMY FOR MALIGNANT HOUR-GLASS CONSTRICTION.

ideal operation, and should only be performed where other methods are not available.

Statistics.—Paterson,[74] in his *Hunterian Lectures*, collected a series of 92 operations for non-malignant hour-glass stomach, of which 76 recovered from operation. For details the reader is referred to the original.

His tables show that gastroplasty has been followed by 25 per cent. and gastrogastrostomy by 30 per cent. of relapses, while gastro-enterostomy alone has given much better results, and the combination of the two former operations along with gastro-enterostomy has been uniformly successful. It seems quite clear that whatever procedure is adopted for making a communication between the two stomach cavities a gastro-enterostomy ought to form part of the operation, in order that the ulceration giving rise to the disease may be cured.

ADHESIONS DUE TO PERIGASTRITIS.

Adhesions of the stomach to adjoining organs or to the abdominal parietes are generally the result of perigastritis due to gastric or duodenal ulcers, though they may result from extraneous causes, such as gall-stones, pancreatitis, hepatic abscess, intestinal ulceration from cancer, typhoid fever, tubercle, or some other lesions setting up peritonitis.

They are frequently a source of great irritation and of severe pain, producing kinking at the pylorus, gastric dilatation, hour-glass contraction, or other gastric disabilities. Adhesions may give rise to severe pain on movement or during the natural peristalsis occurring at the time of digestion, and to various forms of functional dyspepsia.

In 1893, I[76] read a paper before the Clinical Society of London and related a number of cases in which I had been able to relieve long-continued stomach symptoms by dividing adhesions. I can now point to a very large number of cases, considerably over 100, in which gastrolysis, either alone or associated with other operations, has been the means of giving relief in such cases.

Adhesions are found around the stomach or pylorus in about 5 per cent. of all autopsies, and about 40 per cent. of all cases of gastric ulcer are associated with perigastric adhesions. In many cases long before the peritoneum is reached by the ulcer a local peritonitis occurs which fixes the inflamed region to contiguous organs.

My experience in operating for gall-stones shows that pyloric adhesions are extremely common, and, as I pointed out some years ago, the binding of the pylorus to the gall-bladder and bile-ducts by adhesions leads to a frequent association of gastric symptoms with cholelithiasis. I have known of 1 case in which such adhesions apparently led to a fatal termination by causing acute gastric dilatation. In several cases I have seen a band of adhesions stretching across the center of the stomach, leading to hour-glass contraction.

Symptoms.—The symptoms vary according to the site and the cause, but pain is one of the chief; the pain being nearly always increased by exertion, such as riding or running, evidently due to dragging on the adhesions. Adhesions frequently lead to irregular and painful peristalsis, so that the patient complains of gastralgia after food. If dilatation occurs owing to the pylorus being tied up in an abnormal position, there may be signs of retention of food leading to flatulence, chronic dyspepsia, and loss of flesh.

Diagnosis.—The diagnosis in these cases rests on a previous history of some cause that has led to local peritonitis. The pain and discomfort are usually relieved by the recumbent posture, so that a history of enforced recumbency after meals is suggestive. Relief may sometimes be found by the wearing of a belt; this is usually discovered by the patient before advice is sought. As a rule, the pain is increased or brought on by lifting or by reaching with the arms above the head. Active exertion is frequently shunned because of the consecutive pain. If there are adhesions at the pylorus, there is usually rigidity of the right rectus with some tenderness beneath the right costal margin; when the stomach is distended with carbonic acid gas hyperresonance is usually found to extend further to the right than normal.

Gastric adhesions may sometimes give rise to no painful symptoms, though leading to an interference with the motor functions of the stomach. Usually, however, adhesions may be suspected if there is widespread tenderness in the epigastrium associated with rigidity of

the recti, if lavage and other treatment fail to relieve the motor functions, and if after thorough treatment for gastric ulcer the pain and tenderness persist.

Treatment.—If, in cases where general treatment with rest fails to relieve, an exploratory operation shows the cause to be due to adhesions without any other form of disease being manifest, the careful division of adventitious bands until the pylorus is quite free will often yield very gratifying results.

Wherever the adhesions are very firm, and especially when they extend over a wide area, great care must be exercised in separating them, and after they are separated, in carefully examining the stomach or duodenum to see if there is a fistula; for in a number of these cases I have found perforations needing the use of a purse-string suture, which had they not been discovered might have led to serious results. Such adhesions associated with perforation may have been due to a perforating ulcer reaching the surface and leaving the perforated organ firmly adherent.

In order to avoid an immediate recurrence of adhesions I am accustomed in such cases to interpose the omentum between the pylorus and the biliary passages. If adhesions should then form again, they are of a loose character and will probably be unattended by symptoms. If, however, adhesions are very extensive, especially if there is reason to believe that an ulcer may be present in the stomach, a gastro-enterostomy should be performed.

In a number of cases in which I have performed a gastrojejunostomy under these circumstances the results, both immediate and remote, have been excellent.

Adhesions After Operations on the Stomach.—It is most desirable that if possible adhesions should not occur after operation, otherwise the relief may be incomplete. The subject is one of such importance to the surgeon that any exact record of clinical study or experimental work merits attention. Vogel[80] made a number of experiments on animals and studied 5 cases in the human subject, of which 4 had died owing to recurring adhesions causing obstruction. He recommends aseptic instead of antiseptic technic; the avoidance of unnecessary injury to the peritoneum (especially such as is caused by the use of sharp hooks); avoidance of the cautery, and careful suturing, wire being better than silk.

He says Müller's method of using normal saline solution and the employment of gold-beater's skin are not effectual in preventing adhesions re-forming after operation, but that gum arabic solution acts well (gum arabic, 1; normal salt solution, 2, filtered and sterilized). It is applied as follows: After almost complete closure of the wound, a drainage-tube is passed into the abdomen; through this the solution is injected, the tube removed, and the suture completed. To regulate peristalsis, subcutaneous injections of atropin and, still better, salicylate of physostigmin were used. In one case after appendicectomy the latter drug was used in 0.0004 doses, from two to four times daily,

with good effect. Morris[81] speaks of Cargile's method of applying a thin variety of gold-beater's skin from the peritoneum of the ox over roughened peritoneal surfaces to prevent adhesions. In rabbits experimented on, the results were satisfactory. Craig and Ellis's[82] careful researches on animals have shown that the method is unreliable.

GASTRO-ENTEROSTOMY.

Gastro-enterostomy was first performed successfully by Wölfler at the suggestion of Nicoladini on September 28, 1881.

For some years later so little confidence was placed in this and other operations on the stomach that cases were, as a rule, treated medically until almost moribund before surgical treatment was considered advisable, with the result that the mortality was appalling. For instance, between 1881 and 1885 the mortality of gastro-enterostomy was 65.7 per cent. There is, however, a very different statement to make to-day, when, for instance, I can point to my personal experience of a series of over 200 posterior gastrojejunostomies, undertaken for both simple and malignant disease, with a mortality of only 3.4 per cent., and to a series of over 100 cases in my private practise with a mortality of only 1.7 per cent.

These and similar results by other surgeons bring the procedure well within the realm of safety, and seeing that it has to be undertaken in many cases for diseases that would be otherwise inevitably fatal, it may be looked on as an operation the benefits of which not even the most conservative practitioner can afford to ignore. These changes have been brought about not only by patients being operated on at an earlier stage and under more favorable conditions, but also by greater care in technic details, by greater expedition in operating, by more careful asepsis, by the avoidance of or greater care in the use of irritating antiseptics, by the prevention or better treatment of shock, by care in post-operative treatment, such as early feeding subsequently to operation, and by the careful preparation of the patient.

The Preparation of the Patient.—It has been the custom with many surgeons to put patients suffering from disease of the stomach through a long course of preliminary treatment, such as frequent lavage of the stomach and abstention from food before operation. This, as a rule, is quite unnecessary and certainly inadvisable in the greater number of cases: first, because the treatment is depressing and debilitating in the case of patients already exhausted by a long illness; second, as proved by Harvey Cushing's bacteriologic investigations, the stomach contents speedily become aseptic if the mouth be cleansed and aseptic foods administered; and third, as proved by ample clinical experience, elaborate preliminary treatment is unnecessary to success.

If the stomach is greatly dilated and the contents are foul, then lavage with simple boiled water night and morning is adopted for two days before operation. The careful cleansing of the mouth and teeth

and the administration of foods sterilized by boiling are advisable. The last light meal is given the night before, about twelve hours, and a nutrient enema is given about one hour before operation. In ordinary cases no lavage is adopted, but the same care is exercised in cleansing the mouth, giving sterilized food, and administering a nutrient enema consisting of 1 ounce of brandy, 1 ounce of liquid peptonoids, and

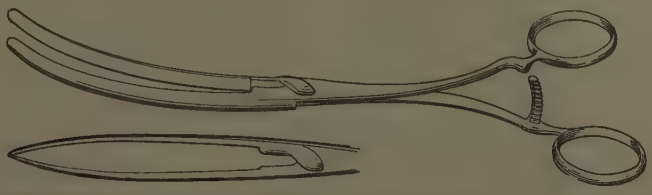

Fig. 455.—Mayo Robson's Clamp for Gastro-enterostomy with Take-off Joint.

10 ounces of normal saline solution. Every patient is enveloped in a suit of cotton wool, and each has an injection of from 5 to 10 minims of liquor strychniæ (B. P.) administered subcutaneously before or during the operation. The preparation of the skin and other aseptic details differ in no respect from those observed in operations generally. Although gastro-enterostomy has been performed in many different ways, there are practically only two distinct methods: One (Wölfler's) in which the jejunum is fixed to the anterior stomach wall, and the other (von Hacker's) in which the anastomosis is effected between the jejunum and the posterior wall of the stomach. From a somewhat extensive experience of the two, I have no hesitation in strongly recommending the posterior, where that operation is possible, for there are some exceptional cases in which, on account of adhesions to the pancreas extensive involvement of the posterior wall of the stomach by growth or from congenital deformity (a very short mesocolon), the anterior method must be selected.

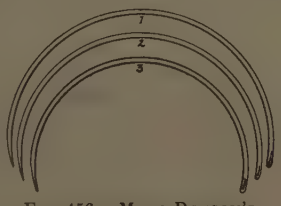

Fig. 456.—Mayo Robson's Needles.

Operation.—The following is a description of the operation which I am in the habit of performing: The abdomen is opened by an incision about 4 inches long, 1 inch to the right of the middle line above the umbilicus. The stomach is thus exposed. Sterilized gauze is laid on the abdomen surrounding the wound. The great omentum and the transverse colon are then lifted up and brought out of the wound, thus exposing the under surface of the transverse mesocolon and the attached part of the jejunum on the left side of the second lumbar vertebra. The bowel is caught up in a clamp, just beyond the duodeno-jejunal flexure, at which place the anastomosis is made, thus avoiding any loop. A vertical slit is then made in the transverse mesocolon between the blood-vessels, which are readily seen. By pressing with the left hand above the colon the posterior wall of the stomach is made to project through the opening in the mesocolon, the lower border of

the stomach being readily recognized by the blood-vessels which are coursing along it. The most dependent part of the stomach close to the lower border is then brought through the slit and grasped by a clamp, as shown in Figs. 457, 458. The great omentum and the trans-

FIG. 457.—POSTERIOR GASTROJEJUNOSTOMY.
Showing posterior wall of stomach close to lower border drawn through slit in transverse mesocolon and grasped by clamp, also jejunum grasped by clamp.

verse colon are then returned into the abdomen above the parts to be anastomosed and covered with a sterilized gauze pad. The two clamped portions of the bowel and stomach are now placed side by side with a strip of gauze behind them. A continuous suture of spun celluloid

FIG. 458.—POSTERIOR GASTROJEJUNOSTOMY.
Showing portions of stomach and jejunum to be anastomosed placed side by side preparatory to applying sutures.

thread in a round half-curved needle is employed to unite the serous surfaces for a distance of from 2 to $2\frac{1}{2}$ inches, the needle being then laid aside still threaded. The two viscera are incised $\frac{1}{4}$ inch in front of this serous suture and the edges are united by a chromic catgut

suture, which takes up all the coats and brings into apposition the mucous membrane of the intestine and stomach. This suture is continued round the circle until it reaches the point where it began, when the suture is at once tied and cut short. The serous suture

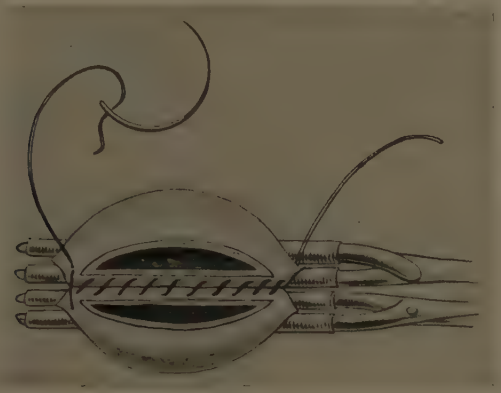

Fig. 459.—The Posterior Half of the First Continuous Serous Suture.

previously laid aside is now taken up and continued round the front half of the circle in front of the newly made opening until the point is reached where it began, when the two ends are knotted and cut short. The edges of the aperture are thus united firmly by a serous and

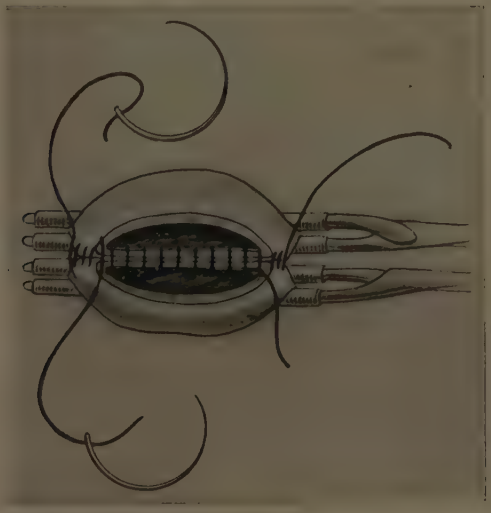

Fig. 460.—The Stomach and Jejunum Opened; the Posterior Half of the Second or Inner Hemostatic Suture.

a marginal suture. The clamps are now removed and the piece of gauze behind the anastomosed viscera is then drawn out and the omentum and stomach are brought down to their normal position. In order that there may be no kinking at the point of junction I am accus-

tomed to place one or two additional sutures on the distal side of the united viscera and to bring the distal part of the jejunum over to the right side of the spine in arranging the visceral toilet. If the slit in the mesocolon is large and not completely filled by the anastomosis, two or three interrupted sutures are used to unite the margin of the mesocolic opening to the stomach or jejunum. The abdomen is closed by a continuous catgut suture, which first unites the peritoneum and the posterior sheath of the rectus together, and the same suture returning unites the anterior sheath of the rectus; but in order to give additional strength to the abdominal wall I usually pass from three to six through-and-through chromic catgut sutures, which, however, do not penetrate the skin and which are cut short and buried beneath it. The skin is then brought together either by continuous catgut sutures, or by several

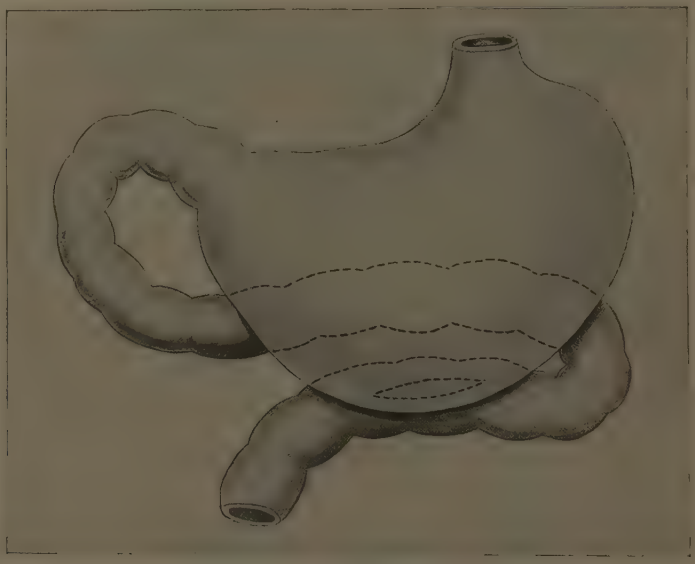

FIG. 461.—GASTROJEJUNOSTOMY.
Showing the relation of the jejunum to the stomach after the anastomosis has been effected.

interrupted silkworm-gut sutures, or by the well-known Michel's metal clips, which I myself prefer.

It will be noticed that I have said nothing of making the opening in the stomach oblique, as suggested by Moynihan, nor of excising redundant mucous membrane, as suggested by Littlewood, nor of displacing the large vessels coursing along the greater curvature, as suggested by W. J. Mayo, for these modifications of the operation are quite unnecessary.

The anastomotic opening should be made close to the lower border of the stomach and the opening should never be less than 2 inches in length. If, as should be the case, the mucous margins of the stomach and bowel are united, there is no fear of serious subsequent diminution of the opening by cicatricial contraction.

The modification I formerly adopted, of inserting a decalcified bone-bobbin before completing the anterior half-circle of the continuous sutures, secures an immediately patent opening and removes the possibility of kinking.

The bobbin is merely a splint around which the sutures are applied and is only a modification of the suture method. The bobbin is dissolved in from twenty-four to forty-eight hours, so that no foreign body is left. It has given me most satisfactory immediate and ultimate results, 1.7 per cent. mortality in simple cases and only 3.4 per cent. in malignant and simple combined.

Fig. 462.—Posterior Gastro-enterostomy with the Aid of Mayo Robson's Bone-bobbin.

The use of the Murphy button is on quite a different principle, as it acts by causing pressure necrosis of the apposed surfaces. It can certainly be done a little quicker, though really very little time is saved; but the two fatal objections to its use are the small size of the opening, which tends to contract, and the danger of the button falling back into and being retained in the stomach; a danger which is proved to have frequently occurred in practise, necessitating in many cases a further operation. . I, therefore, personally never employ it and cannot recommend its use to others.

It is only fair, however, to state that Murphy has made recent changes in his button to obviate the objections to the old round button which he at first used. He now employs a long, narrow device made

on the same principle as the original button, which gives a much more satisfactory opening. It is also made heavier and larger on the intestinal side, so as to prevent its passage into the stomach.

A modification of the posterior operation has been suggested by W. J. Mayo,[84] which has given him very satisfactory results. The operation which is shown in the diagrams consists in attaching the jejunum to the stomach from right to left, thus avoiding what Mayo calls the reversing of the duodenum.

The suggestion of McGraw to make the incision safer by the employment of an elastic ligature is, to my mind, neither necessary from

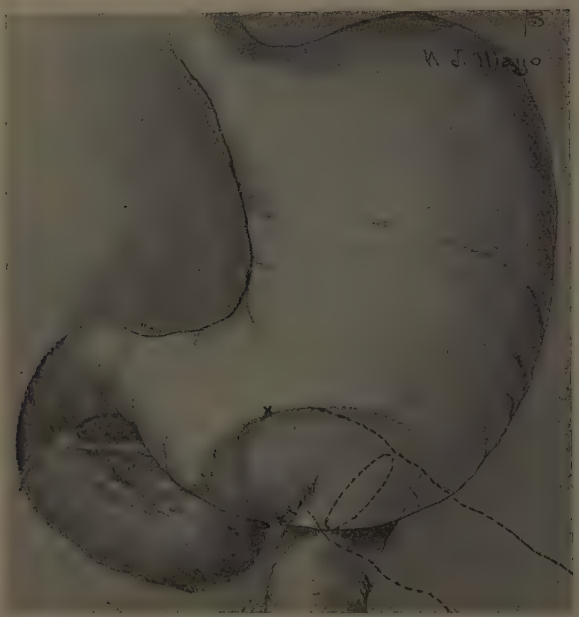

FIG. 463.—SHOWING KINK IN JEJUNUM RESULTING FROM CHANGING NORMAL DIRECTION OF ITS UPPERMOST PORTION IN "NO-LOOP" GASTROJEJUNOSTOMY AFTER POSTERIOR METHOD. (Wm. J. Mayo.)

x and x mark commencement of jejunum.

the point of view of safety nor desirable from that of accuracy; moreover, as the anastomosis has to be made by a process of sloughing, which takes some days to complete and always leads to an opening of uncertain size and one with a tendency to contract, I have the feeling that the method, though ingenious, is clumsy and inexact and one which should not be employed by a surgeon who is capable of adopting the more exact t chnic herein described.

When an operation involving so many possibilities of danger and often undertaken in very serious conditions can be accomplished with a little over 1 per cent. mortality in over 100 consecutive cases of ulcer and other simple disease of the stomach, there cannot be much seriously wrong with the technic, and when I see alternative methods suggested, such as Roux's Y operation or that of short-circuiting the

FIG. 464.—SHOWING NO KINK IN JEJUNUM RESULTING FROM PRESERVING NORMAL DIRECTION OF ITS UPPERMOST PORTION IN "NO-LOOP" GASTROJEJUNOSTOMY AFTER POSTERIOR METHOD. (Wm. J. Mayo.)

x and x mark commencement of jejunum.

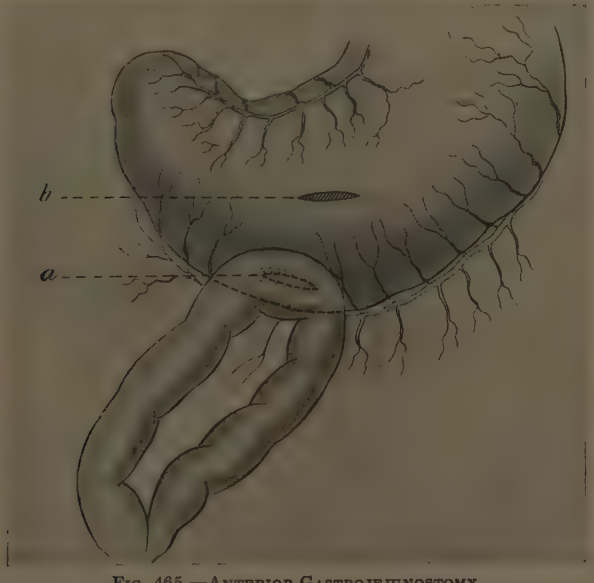

FIG. 465.—ANTERIOR GASTROJEJUNOSTOMY.

Showing the correct position (*a*) and the incorrect position (*b*) for the anastomosis.

jejunal loop, both of which involve the making of a double anastomosis in order to avoid the complication of the vicious circle, a complication which does not occur when the operation I have described in detail

is performed, I am at a loss to understand why such operations continue to be done save under very exceptional circumstances. Other methods, however, ought to be described.

Anterior Gastro-enterostomy.—Anterior gastro-enterostomy is performed like the posterior, except that in this case the anastomosis of the jejunum with the stomach is made at the lower border of the anterior surface; and instead of the attachment being made close to the commencement of the jejunum, it has to be effected at least 12 to 15 inches from the flexure, since the jejunal loop has to pass over the transverse colon in order to reach the point of attachment to the stomach. Otherwise it differs in no respect from the posterior operation.

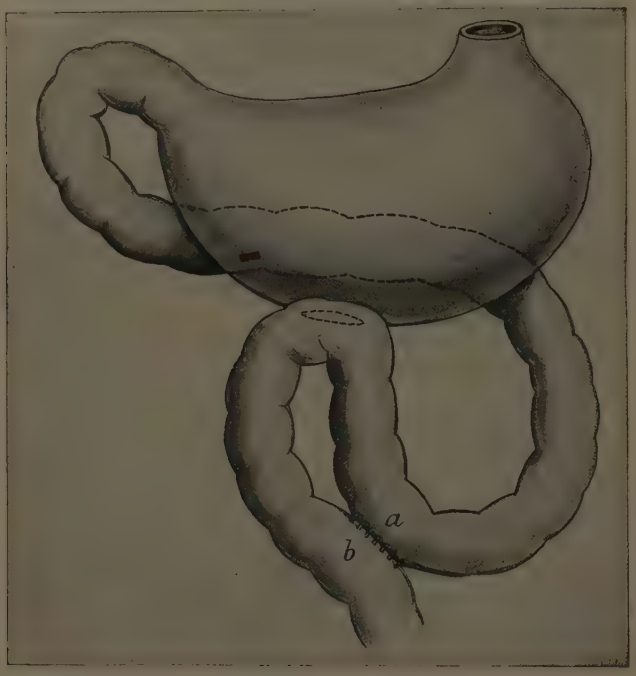

FIG. 466.—ANTERIOR GASTROJEJUNOSTOMY.
Showing the long loop necessary to encircle the colon short-circuited into the distal loop of the jejunum. Entero-anastomosis of the jejunal loop.

The disadvantage, as we shall see later, is in the long loop of jejunum, which is apt to give rise to several complications. Personally I always perform the posterior operation, except—(1) when the mesocolon is very short, giving no room through which to make the anastomosis; (2) when extensive and firm adhesions of the posterior wall of the stomach prevent a portion being drawn through a slit in the mesocolon, and (3) when cancer invades the posterior wall so extensively as to leave no part of it safely available for operating on.

Entero-anastomosis of the Jejunal Loop.—This operation has been suggested as a means of preventing the vicious circle or of arresting it should it unfortunately have occurred.

In posterior gastro-enterostomy without a loop or with a very short interval between the duodenojejunal flexure and the anastomotic, an entero-anastomosis is neither necessary nor desirable, as the vicious circle does not happen if the operation has been properly performed.

After the anterior operation, with the necessarily long jejunal loop, stagnation of fluids may occur in it giving rise to regurgitant vomiting or to inflammation or ulceration of this part of the jejunum.

Some surgeons who regularly perform the anterior operation adopt entero-anastomosis as part of the technic, employing it as a preventive method.

I have only had to perform the operation on three occasions, and on each after anterior gastro-enterostomy. The operation is performed

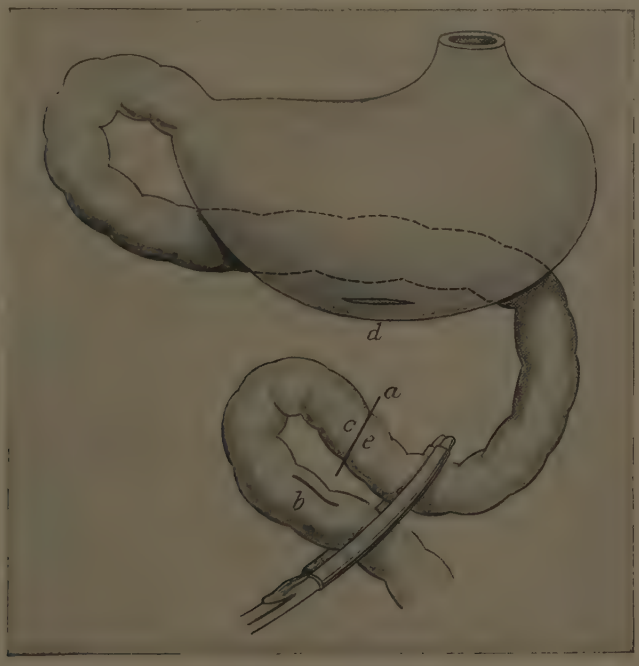

FIG. 467.—ROUX'S OPERATION.

as follows: The lowest part of the ascending limb of the loop (*a*) is grasped by a rubber-covered clamp and approximated to a part (*b*) on the descending coil of jejunum beyond the gastrojejunal opening, which is also clamped, and an opening of from 1 inch to 2 inches is made between one and the other, exactly as already described for making the opening between the stomach and jejunum.

Roux's Operation.—This method, which is also spoken of as the Y operation, was suggested and carried out by Roux, and is, I believe, still performed by him and by some other operators as a routine procedure.

This operation was invented when regurgitant vomiting or the

vicious circle was a frequent complication of gastro-enterostomy and then it was a distinctly useful modification, as it still is when a posterior gastro-enterostomy cannot be performed on account of extensive adhesions or from extent of growth. As an ordinary procedure Roux's operation is not necessary and I think it undesirable, as it involves a double anastomosis.

It is performed as follows: After clamping the portion of stomach to which the anastomosis is to be made, a loop of jejunum of about 9 inches, about 10 inches from the duodenojejunal flexure, is grasped by a pair of long rubber-covered clamps (Fig. 467). This loop is divided at *a*, the open end of the bowel *e* is sutured to a lateral opening made into the other arm of the loop at *b*. The open end *c* is then

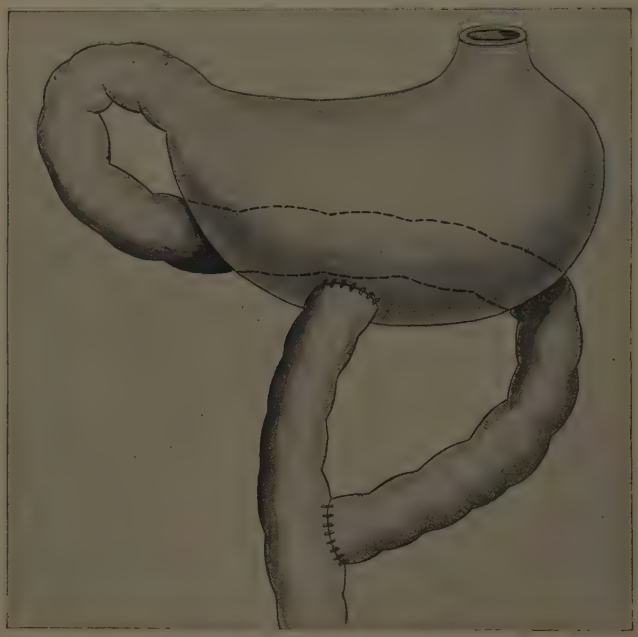

FIG. 468.—ROUX'S OPERATION.

stitched to an opening made into the stomach at *d*. When completed the operation presents the appearance shown in Fig. 468.

I have carried out the procedure with advantage in extensive perigastritis with matting of the viscera, in widespread gastric carcinoma, and in jejunal ulcer where it was necessary to excise part of the ulcerated jejunal loop.

Indications for the Performance of Gastro-enterostomy.—The following are the indications for the operation of gastro-enterostomy. They cannot be stated in one category, for while in the first series the indications, with certain provisos, are absolute so soon as the diagnosis is established, in the second series the indications for the operation apply only after failure of general treatment. In the first series are:

1. Simple stenosis of the pylorus. 2. Malignant stenosis of the pylorus not suitable for excision. 3. Congenital stenosis. 4. Congenital atresia. 5. Chronic gastric ulcer with tumor of doubtful character, too extensive or adherent for effectual removal, not necessarily associated with stenosis. 6. Duodenal cancer or tumor causing obstructive symptoms. 7. Hour-glass contraction of the stomach not favorable for gastroplasty or as an addition to that operation. 8. Perigastritis with adhesions round the pylorus, producing obstructive symptoms or pain and too extensive for simple gastrolysis. 9. Dilatation of the stomach dependent on pressure on or beyond the pylorus from tumor or congenital abnormality of the pancreas, or from tumor of the liver or gall-bladder, incapable of removal.

In the second series, after failure of medical treatment, are: 10. Acute or chronic gastric ulcer. 11. Duodenal ulcer. 12. Persistent spasm of pylorus or Reichmann's disease, with dilatation of the stomach. 13. Hemorrhage from gastric or duodenal ulcer. 14. Hyperchlorhydria that has failed to yield to general treatment. 15. Persistent gastralgia in which medical treatment has failed to give relief. 16. Tetany of gastric origin. 17. Acute gastric dilatation not yielding to lavage and general treatment. 18. Pancreatitis secondary to gastric ulcer. 19. Certain cases of jaundice dependent on gastric or duodenal ulcer, leading to thickening around the common bile-duct. 20. Simple atonic dilatation of the stomach, only after failure of lavage and general treatment, long continued.

Complications.—The complications that may follow gastro-enterostomy are: 1. Regurgitant vomiting. 2. Contraction of the new orifice. 3. Peptic jejunal ulcer. 4. Pneumonia or other complications in the chest. 5. Adhesions. 6. Intestinal obstruction. 7. Non-union and separation of the anastomosed viscera. 8. Hernia of the intestine through the loop in the anterior or through the mesenteric slit in the posterior operation. 9. Exhaustion. 10. Hemorrhage. 11. Dragging on the jejunum, when a dilated stomach retracts, if the ligament of Treitz is short or displaced to the right of the stomach and there is no jejunal loop.[86]

1. **Regurgitant Vomiting.**—Regurgitant vomiting is a complication that used frequently to follow the operation of gastro-enterostomy and when severe it was not infrequently fatal. It is now seldom and should never be seen, as it is entirely due to faulty technic.

It is essentailly due to obstruction to the passage onward of the duodenal contents, either from paresis of the intestine that has been handled too freely or paralyzed by the too firm pressure of a faulty clamp; or to kinking of the bowel at the point of anastomosis; or to some obstruction by adhesions or pressure beyond the gastrojejunal opening. In other words, it is an acute intestinal obstruction.

The theories that have been put forward to account for it are:

(*a*) The presence of bile in the stomach, which Dastre's experiments on dogs absolutely disproved.[87]

(*b*) The presence of a loop on the proximal side of the opening

into the stomach, which is disproved by the large numbers of successful anterior gastro-enterostomies that must necessarily have such a loop.

(*c*) By the situation of the opening not being at a dependent part of the stomach, also disproved by many of the early successful cases in which the opening was not made close to the lower border of the stomach.

(*d*) The presence of pancreatic fluid in the stomach, disproved by Moynihan's case, in which a ruptured intestine at the duodenojejunal flexure was treated by closing both ends of the rupture and performing a gastrojejunostomy, so that all the bile and pancreatic fluid regurgitated into the stomach through the pylorus for the fourteen weeks during which the patient survived the accident without there being any signs of vicious circle.[88]

(*e*) The formation of a spur at the point of anastomosis which by preventing the onward passage of the stomach contents may undoubtedly be a cause; but this will not occur if the technic described on p. 249 is followed.

(*f*) Acute angulation of the jejunum beyond the anastomotic opening; a well-recognized cause, readily avoided by one or two anchor sutures beyond the opening.

(*g*) Pouting valves of mucous membrane. This may be a cause, but it is readily avoided by the proper application of the marginal suture, securing apposition of the intestinal to the gastric mucous membrane.

(*h*) Compression of the colon by the jejunal loop in the anterior operation (Doyen).

(*i*) Adhesions forming subsequent to the operation leading to constriction of the distal arm of the jejunum, as in a case under my care in 1901, which was operated on six months later and cured by the division of a band crossing the distal jejunal loop.[89]

It will thus be seen that the causes of the vicious circle are avoidable and the complication should, therefore, seldom if ever occur, and, in fact, since recognizing the cause in 1901, I have never seen a case of regurgitant vomiting.

Treatment of the Vicious Circle.—This should be prevented by accuracy of technic, and if the following points are observed the vicious circle will not occur: (1) Accurate union of the mucous margins of the stomach and jejunum. (2) Securing the anastomotic opening at or near the lower border of the stomach. (3) Applying one or more anchor sutures beyond the point of anastomosis. (4) Bringing the distal loop of jejunum over to the right of the spine in arranging the peritoneal toilet before closing the abdomen. (5) Making the anastomosis in the posterior operation either without a loop or with a very short interval between the anastomosis and the jejunal flexure. (6) In the anterior operation the loop must not be made too short so as to compress the colon.

If the technic has been faulty and, unfortunately, regurgitant vomiting should occur, what can be done? (1) Raise the head and

shoulders so as to prop up the patient in a semirecumbent posture. (2) Wash out the stomach and repeat it if necessary. (3) Feed by the bowel and stop mouth-feeding for a time. (4) Give small doses of calomel in repeated doses followed by enemeta to try to secure a movement of the bowels. (5) If these fail, do not wait too long before reopening the abdomen and performing entero-anastomosis, an effectual method of treatment.

2. **Subsequent Contraction of the Anastomotic Opening.**—Although there may be moderate contraction of the new opening, both in cases where the stomach is greatly dilated before operation and in those where the pylorus is patent at the time of operation; yet, if the anastomotic opening be made sufficiently large, not under 2 inches, and the union of mucous membrane to mucous membrane be efficiently performed, contraction to a serious extent will not be likely to occur. In all such cases, and in those where I have used a decalcified bone-bobbin at the time of operation, I have always found the opening to be patent where I have at long periods subsequent to operation had to operate again for some other cause.

W. J. Mayo,[95] in 1902, reported 4 cases in which contraction at the site of anastomosis took place. These all followed the use of the Murphy button and occurred in cases where the pylorus was not occluded.

In operations for ulcer of the stomach it seems highly probable that the reason for want of relief in some of the cases has been owing to the anastomotic opening being made of too small a size, when any subsequent slight contraction becomes of serious moment. This was demonstrated satisfactorily by Paterson in his *Hunterian Lectures* in 1906.[96]

3. **Peptic Ulcer of the Jejunum.**—The subject of peptic ulcer is an extremely interesting one, that has given rise to much speculation and to many theories.

In the stomach it is extremely common, in the duodenum probably much more frequent than hitherto supposed, but in the jejunum it is generally thought to be very rarely found; in fact it was only in 1899 that Braun first described the formation of peptic ulcer in the jejunum of man, and although the subject has since received attention in Germany by Hahn, Kausch, Korte, and others, my own case in 1904 was the first described in English literature. In that paper I referred to several cases, but Mikulicz has since reported other cases. Several additional ones were mentioned by Paterson[96] in his *Hunterian Lectures*, and Gosset[99] collected from all sources no less than 30 cases; the disease is, therefore, not very uncommon.

As all of these cases were perforating ulcers it almost goes without saying that there must be many more that have existed unrecognized, and probably others that may have caused death by abscess and in other ways in which the adhesions and other complications have so obscured the parts that even an autopsy has failed to elucidate the true nature of the disease.

The true cause of peptic ulcer, whether gastric, duodenal, or jejunal, is probably a mild form of sepsis leading to gastritis and excess of free HCl in the gastric juice. Traumatism, either by coarse food or through external injury and interference with the circulation in the bowel, has been assigned as a cause, but without what seems to me adequate reason. It has only once occurred after gastrojejunostomy for cancer.

Peptic ulcer is distinctly one of the sequelæ to be reckoned with after gastro-enterostomy. An analysis of the cases shows it to occur more frequently after the anterior than the posterior operation. Of 27 cases collected by Gossett, 15 followed anterior gastrojejunostomy; 4, anterior and entero-anastomosis; 1, Roux's Y operation; 6, posterior gastro-enterostomy; 1, posterior and entero-anastomosis.

It is curious that so far as we know it does not occur after pyloroplasty, but whether the operation of Finney, which makes a much more extensive opening, will be followed by peptic duodenal ulcer time alone will prove.

As regards the frequency of peptic jejunal ulcers, out of over 300 posterior gastro-enterostomies which I have personally performed I have had but one example, though I have operated on 3 cases, 2 after operation by other surgeons.

My single case occurred after an anterior gastro-enterostomy, one out of 30 that I have performed; and Kausch reported 2 out of 160 gastro-enterostomies performed in Mikulicz's clinic, both being after anterior gastro-enterostomy.

Treatment of Peptic Jejunal Ulcer.—In the cases of gastric ulcer that have failed to yield to medical treatment and in which gastro-enterostomy has been performed, I fear that we have not properly grasped the fact that the operation, though an important one, is still only an incident in the treatment, which ought to be continued on general lines for some time longer or until good health is again established. Greater attention to oral asepsis and to the gastric condition of hyperchlorhydria subsequent to operation is advisable, and in this way the very serious complication of peptic ulcer in the jejunum and relapses in gastric ulcer might be prevented.

In all the cases reported perforation, associated with acute, subacute, or chronic symptoms, has occurred; hence there can be no question as to the desirability—nay, as to the absolute necessity—of operation, which ought not to be delayed too long. When the abdomen is opened the treatment will depend on the condition found.

Though peptic ulcer of the jejunum is less frequent after posterior gastro-enterostomy, only 2 cases having been recorded, when it does occur it is more likely to be acute and not to be limited by adhesions. An ulcer of the jejunum may occur at any time from seven days to six or seven years after operation; it may be single or multiple and may occur at any point from the site of anastomosis to several inches below it or above it.

If, as in the greater number of cases, adhesions have formed, the condition will be less acute, although very distressing, from the asso-

ciated pain due to perigastritis and adhesions. It will be necessary to detach adhesions and to repair the perforation, but probably in the greater number of cases an excision of the portion of intestine involved and the performance of Roux's operation will give the best results. In my case, which occurred three years and four months after an anterior gastro-enterostomy, I excised the portion of jejunum involved and performed Roux's operation, which was followed by recovery.

4. **Chest Complications.**—I have not found pneumonia and pleurisy to follow operations on the stomach any more frequently than other abdominal operations. The shoulders and head should be well propped up by pillows after operation, and I believe that my good results have been partly due to the use of chloroform. The change of position to avoid the hypostatic congestion of the bases is important.

5. **Perforation Owing to Want of Union at the Point of Anastomosis.**—This is an extremely serious complication and probably almost universally fatal. I have never known it to occur after union by suture, but once saw it happen some years ago in one of the few cases in which I employed the Murphy button, and W. J. Mayo has reported 2 cases that occurred under similar conditions. In one the accident followed an epileptic seizure on the ninth day, in the other, on the seventh day, after gastro-enterostomy for malignant disease of the pylorus.

Want of union used to be less rare when moribund patients were operated on, but it is seldom seen now except when the Murphy button has been used, in which case there is nothing to prevent extravasation if union be delayed beyond the first few days; whereas, if union is effected by a double line of sutures, delayed healing, if not too long, is not serious.

Mumford described a case of separation of the viscera in a case of posterior gastro-enterostomy performed by the no-loop method, which he ascribed to a short ligament of Treiz, so that when the dilated stomach contracted it forcibly dragged on the attached jejunum and led to separation.

6. **Adhesions Subsequent to Gastro-enterostomy.**—Perigastritis or adhesive peritonitis at a distance from the site of operation is probably uncommon after aseptic operations, though adhesions may result from the use of strong antiseptics or if hemostasis is imperfect. Adhesions the result of ulcer and cancer are extremely common, and I have seen adhesions so extensive that it was almost impossible to find any healthy portion of the stomach to which the jejunum might be applied. Under these circumstances on account of obliteration of the lesser peritoneal cavity a posterior gastro-enterostomy may be impossible, and it is better to perform Roux's anterior Y operation. In one case of this kind, though an immediate successful result was obtained by Roux's operation, the symptoms recurred some months later, evidently due to the formation of further adhesions. In another case, in 1891, I had to operate for bilious vomiting that came on some months after gastro-enterostomy, which I found on exploration was

caused by a band stretching from the transverse colon and compressing the efferent jejunal loop, relief being given by the division of the band and an entero-anastomosis.

7. **Internal Herniæ.**—Internal herniæ after gastro-enterostomy may occur under three conditions:

(*a*) The passage of small intestine through the loop formed above the junction of the jejunum and stomach. This condition is only likely to occur after the anterior operation, as in a case reported by W. J. Mayo.[95] The accident happened a year after an anterior gastro-enterostomy.

FIG. 469.—STRANGULATION OVER AFFERENT LOOP. (Barker.)

A, Afferent jejunum coming out from under the plica duodenojejunalis (*B*); *C*, termination of the afferent duodenum dragged back to the hidden anastomosis from which (*D*) the efferent jejunum is passing in its turn over the afferent portion (*A* to *C*); *G*, last part of the ileum twisted round the efferent jejunum and terminating in (*I*) the end of the ileum at the ileocecal valve; *H*, distended coils of the jejunum in the general cavity of the abdomen; *K*, coils of the ileum in the general cavity of the abdomen. It is seen from this diagr m that the *whole* of the small intestine with the exception of the first and last 7 or 8 inches passed behind the gastro-enterostomy junction and was strangulated over the afferent portion, where it formed a large volvulus.

(*b*) There are several cases on record of the passage of small intestine through the slit in the mesocolon made for the anastomosis in posterior gastro-enterostomy. A case of this kind occurred in one of Moynihan's patients, who died on the tenth day of acute intestinal obstruction, when a great part of the small intestines were found in the lesser peritoneal cavity.[90]

The accident may be avoided—

(1) By not making the opening too large; (2) by the use of the decalicified bone-bobbin, which fills up the opening for the first forty-

eight hours; (3) by suturing the margin of the opening to the stomach or jejunum.

(c) Barker[92] has recorded a case in which two years after a posterior gastro-enterostomy nearly the whole of the small intestines passed over the afferent loop and became strangulated (see Fig. 469).

In the operation I have described such an accident could not occur, as there is no long jejunal loop.

8. **Death from Asthenia.**—In the 80's and early 90's it was considered absolutely essential to abstain from feeding by the mouth after any operation on the stomach, and as gastric operations were then always delayed until the patient was extremely weak, it followed as a necessary consequence that asthenia or, in other words, starvation was a real danger.

Asthenia from this cause is now seldom seen, as feeding is begun as soon as the patient has recovered from the anesthetic. In my own practise I do not hesitate to let the patients have liquid or semiliquid nourishment in small quantities every half-hour as soon as they can take it, and seeing that in gastro-enterostomy anesthetic vomiting does not occur, the patient is usually able to have some food within four hours after the operation, this being supplemented by nutrient enemata of normal saline solution containing liquid peptonoids and brandy.

9. **Hemorrhage.**—Hemorrhage as a cause of death after gastro-enterostomy is not likely to occur as the result of the operation itself; as the continuous suture applied through the whole thickness of the margins of the anastomotic opening acts as an efficient compress to the vessels. It may, however, occur from ulcer or cancer, just as it might have happened had no operation been done in such cases. The administration of adrenalin, the abstention from mouth-feeding, and the injection of lactate of calcium under the skin or by rectal enemata will be found useful, and the treatment will be the same as in other cases of hematemesis or melena. Should the bleeding persist the question of further operation in order to discover and treat the bleeding points will arise.

The After-results of Gastrojejunostomy.—1. In considering the various complications, it seems quite definitely proved that the use of the Murphy button is attended with uncertain results, both on account of the subsequent tendency to contraction of the anastomotic opening and the retention of the metal instrument in the stomach.

2. If the anastomotic opening be made of too small a size it is apt to prove unsatisfactory and to lead to relapse.

3. The methods which do not secure continuity of the mucous membranes of the anastomosed viscera are apt to be followed by undue contraction or even complete closure of the new passage.

4. The risk of peptic jejunal ulcer, even after all methods that have been described, is probably under 2 per cent., but if the posterior operation be performed and the anastomotic opening be made sufficiently large, the risk is hardly appreciable, certainly nothing like 1 per cent.

5. If the method of union by suture that I have described be performed and the opening be made of sufficient size, considerably over 90 per cent. of patients suffering from pyloric stenosis of a simple character or from gastric ulcer will be completely and permanently relieved of their symptoms.

6. As a number of patients have regained their normal weight and lived for many years in good health, some even for twenty years, there seems to be no reason to suppose that the operation of gastro-enterostomy (*per se*) tends to shorten life.

Chemicopathologic Evidence.—The experiments performed by Joslin[93] were carried out on patients who had had gastro-enterostomy performed for cancer of the pylorus. His conclusions, therefore, which seem to prove that the operation leads to a marked diminution of absorption of nitrogenous foods as well as of fats and hydrocarbons, cannot be taken seriously, as cancer itself is capable of producing these results. Moreover, Paterson and Goodbody[94] carried out a series of experiments on 4 patients in whom gastro-enterostomy had been performed for simple disease of the stomach, which proved very clearly that metabolism is practically unaffected after gastrojejunostomy, as in none of the cases did the unabsorbed nitrogen amount to more than 2 per cent. above the amount usually passed in the feces by a healthy individual, while the amount of fat passed unabsorbed did not on any occasion exceed 7.7 per cent. of the fat taken in the food, that is just over 2 per cent. above the amount usually passed in the feces by a healthy man.

GASTRODUODENOSTOMY.

Gastroduodenostomy was first suggested by Jaboulay in 1892, and he performed the first operation in 1894. Modifications were adopted by Kümmell and Villard, as shown in the diagrams. The anastomosis

FIG. 470.—GASTRODUODENOSTOMY. JABOULAY'S METHOD.

is made between the pyloric end of the stomach and the anterior surface of the duodenum.

Kocher[100] showed how the duodenum could be mobilized by dividing the peritoneum passing from its right side, thus rendering the operation

simpler and making it more feasible. The operation admirably fulfils the indications for treatment in simple stenosis of the pylorus, and Kocher is of opinion that it will take precedence over all other methods

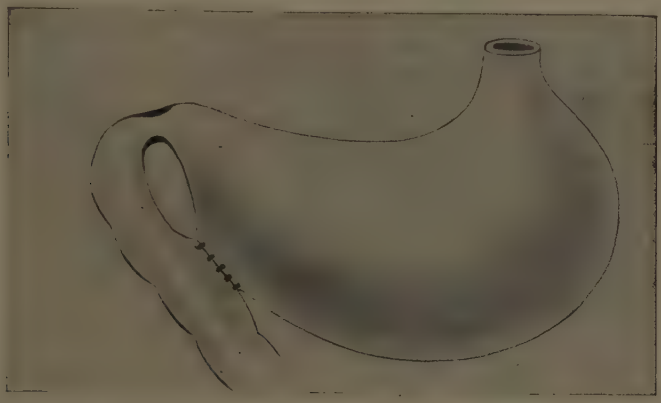

FIG. 471.—GASTRODUODENOSTOMY. KOCHER'S METHOD.

of short-circuiting the stomach and intestines. It is not, however, applicable to cases of cancer of the pylorus nor can it be readily performed where the pylorus and duodenum are fixed by adhesions nor

FIG. 472.—GASTRODUODENOSTOMY. KÜMMELL'S METHOD.

advisedly done where the stomach is very much dilated and sacculated, as gastroduodenostomy does not give such perfect drainage as does gastrojejunostomy.

PYLOROPLASTY.

The principle in plastic union of incising a stricture longtitudinally and bringing the margins of the incision together transversely, invented by Heinecke and applied in 1886 to stricture of the pylorus, is a method of the first importance and of wide application in general as well as in abdominal surgery. It was taken up by Mikulicz in 1887,

and he suggested that the incision, instead of being made straight, should be extended downward, both into the duodenum and stomach. The operation, so modified and known as pyloroplasty, usually is called the Heinecke-Mikulicz operation.

It is performed as follows: The stomach having been exposed, the pylorus is drawn into the wound and surrounded with sterilized gauze. The stricture is then divided by an incision which must extend at least 1 inch on each side into the duodenum and stomach respectively. This incision may be commenced from the stomach side and prolonged through the pylorus into the duodenum, either by scissors or by a scalpel guided along, a director passed through the constriction. Nibbed forceps are then applied to the middle of the upper and lower lips of the incision. On pulling these upward and downward the longitudinal incision becomes transverse, and in this position it is sutured. Two layers of stitches (both continuous) are then applied; the inner, of chromic catgut, embraces all the coats and secures union of the mucous margins; the outer, of celluloid thread, takes up the peritoneum.

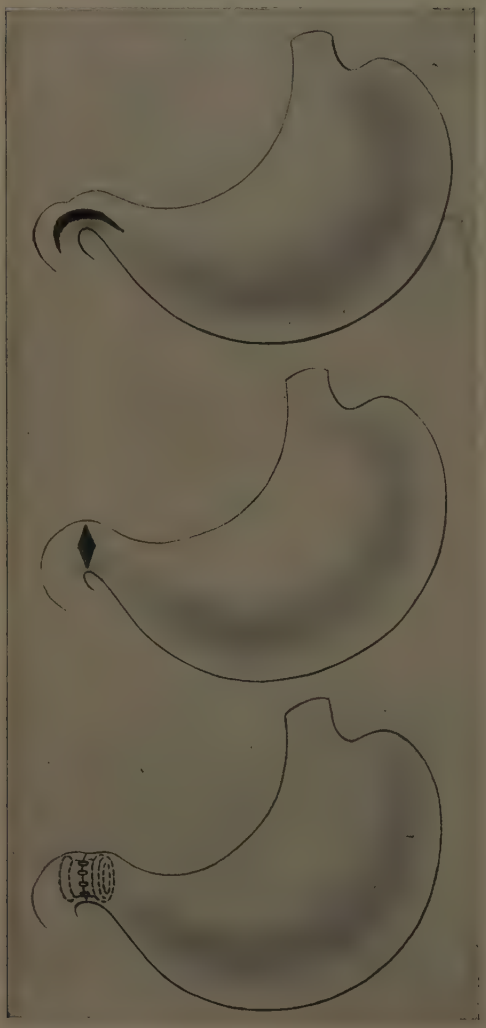

FIG. 473.—PYLOROPLASTY AS MODIFIED BY THE USE OF A DECALCIFIED BONE-BOBBIN. (Mayo Robson.)

In 1895, in order to overcome the tendency to subsequent contraction, I modified the operation by inserting a decalcified bone-bobbin and applying the sutures over it so as to secure an immediately patent and wide opening in which the line of suturing would be protected from the acid contents of the stomach for forty-eight hours or thereabouts. Fig. 473 shows the principle of the operation.

The main point necessary for success is that the incision should be of ample length and that it should not be performed where there is

active ulceration or where the pylorus is fixed by adhesions, the result of perigastritis. The rôle of pyloroplasty is, therefore, a limited one.

The after-results in many cases are not nearly so satisfactory as are those of gastrojejunostomy, as it is apt to be followed by adhesions with anchoring of the pylorus at a very high level, thus creating a difficulty in the stomach emptying itself. The greatest objection is the tendency to contraction of the new orifice.

Though the operation has little immediate risk, the ultimate results are not uniformly satisfactory, for while of the 28 pyloroplasties that I have performed there was only 1 death, due to perforation, of those that recovered, 8 have required a subsequent operation; 1 was quite well for nine months and died of tetany some time later, and 2 are said to have developed cancer after six years and eight months of good health. In 16 the results have been excellent and the patients are in good health from four to eleven years later.

Rutherford Morison advocates pyloroplasty in preference to gastro-enterostomy, but out of his 28 cases relapse occurred in 4 and necessitated gastro-enterostomy. W. J. Mayo had 21 cases without a death, but of these 7 required a secondary operation. Paterson[101] states that of the cases he collected 27 per cent. of the patients subsequently relapsed.

Cannon and Blake,[102] after an experimental study by means of the Roentgen rays on stomachs containing bismuth, came to the conclusion that pyloroplasty was superior to gastro-enterostomy.

An important modification of pyloroplasty was suggested by Finney, which really consists of a prolongation of the incision suggested by Mikulicz, so as to make a wide communication between the stomach and duodenum.

Finney's Operation.—The following is Finney's[104] description of the operation, suggested by him in 1902:

Divide the adhesions binding the pylorus to the neighboring structures, also free as thoroughly as possible the pyloric end of the stomach and first portion of the duodenum. Upon the thoroughness with which the pylorus, lower end of the stomach, and upper end of the duodenum are freed depends, in large measure, the success of the operation, and the ease and rapidity of its performance; this is one of the most important points in the operation. Frequently, at first sight, the pylorus may be seen hopelessly bound down, when after a little patient toil and judicious use of the scalpel and blunt dissector it is found that it can be freed with comparative ease. A suture, to be used as a retractor, is taken in the upper wall of the pylorus, which is then retracted upward. A second suture is then inserted into the anterior wall of the stomach and a third into the anterior wall of the duodenum, at equidistant points, say about 12 cm., from the suture just described in the pylorus. These second sutures mark the lower ends of the gastric and duodenal incisions respectively. They should be placed as low as possible in order that the new pylorus may be amply large. Traction is then made upward on the pyloric suture and downward in the same

plane on the gastric and duodenal sutures. This keeps the stomach and duodenal walls taut and allows the placing of the sutures with greater facility than if the walls remained lax.

The peritoneal surfaces of the duodenum and stomach along its greater curvature are then sutured together as far posteriorly as possible.

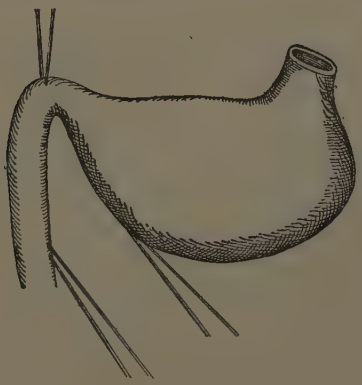

FIG. 474.—FINNEY'S PYLOROPLASTY.
The retractor sutures.

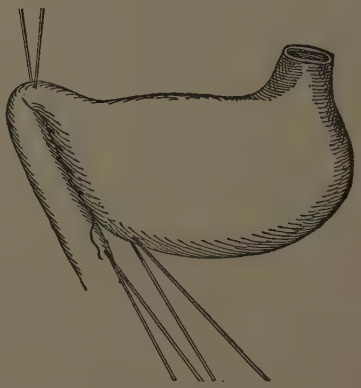

FIG. 475.—FINNEY'S PYLOROPLASTY.
Suture of greater curvature of stomach to duodenum.

For this row the use of the continuous suture is advisable, as it is more easily and quickly applied and it can be reinforced after the stomach and duodenum have been incised. After the posterior line of

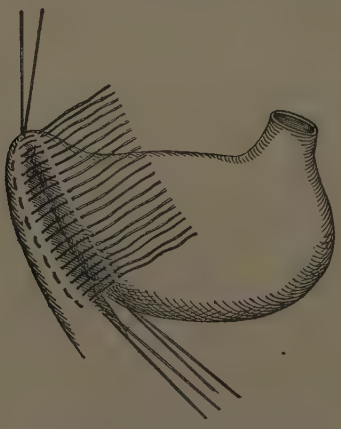

FIG. 476.—FINNEY'S PYLOROPLASTY.
Shows the three retractor sutures, the posterior line of sutures tied and the anterior line of sutures untied.

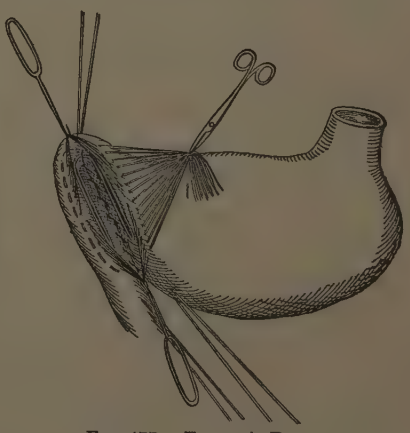

FIG. 477.—FINNEY'S PYLOROPLASTY.
The anterior sutures gathered and lifted.

sutures has been placed an anterior row of mattress sutures is inserted, which are not tied, but left long.

These sutures, after they have been placed, are retracted vertically in either direction from the middle of the portion included in the row of sutures.

Then, after all the stitches have been placed and retracted, the incision is made in the shape of a horseshoe. The sutures should be placed far enough apart to give ample room for the incision. The gastric arm of the incision is made through the stomach wall just inside the lowest point of the line of sutures, and is carried up to and through the pylorus and around into the duodenum, down to the corresponding point on the duodenal side. Hemorrhage is then stopped. It is well to excise as much as practicable of the scar tissue upon either side of the incision in order to limit, as far as possible, the subsequent contraction of the cicatrix. This procedure was carried out in 2 cases with great satisfaction, and is to be strongly recommended in all cases where the walls of the pylorus are much thickened and there is much scar tissue present. It is well, too, to trim off with scissors redundant edges of mucous membrane in order to prevent the formation of a valve-like fold of mucous membrane at the new pylorus. A continuous catgut suture is now taken through and through all the coats of the intestine on the posterior side of the incision.

FIG. 478.—FINNEY'S PYLOROPLASTY. The continuous posterior catgut suture.

FIG. 479.—FINNEY'S PYLOROPLASTY COMPLETED BY TYING THE ANTERIOR SUTURES.

This reinforces the posterior line of sutures, secures better approximation of the cut edges of the mucous membrane, and prevents the reunion of the divided intestinal walls. The anterior sutures are then straightened out and tied and the operation is complete, unless one wishes to reinforce the mattress sutures with a few Lembert stitches.

This procedure, as is readily seen, gives the minimum of exposure of infected surface. All the stitches are placed and the posterior row tied before the bowel is opened, and it remains open just long enough to control the hemorrhage. The size of the newly formed pyloric opening in this operation is limited only by the mobility of the stomach and duodenum and the judgment of the operator. In all Finney's cases the incision was about 12 cm. in length and could have been made longer had it been necessary. Unless the stomach is very much

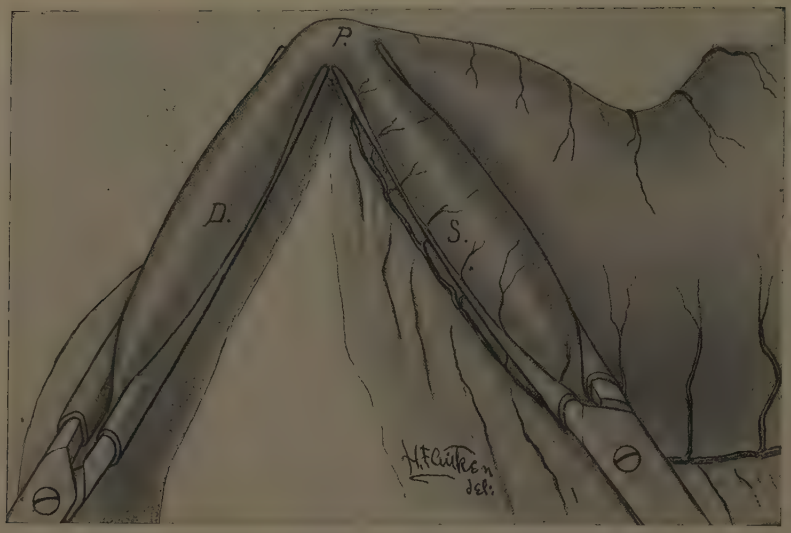

FIG. 480.—GOULD'S MODIFICATION OF FINNEY'S OPERATION.

Note application of clamps. On the stomach they are placed parallel with the greater curvature, thus controlling the hemorrhage from the vessels which are seen crossing line of future incision. Inner jaws of both clamps touch at the pyloric angle. When the handles are brought together the pyloric angle (*P*) is put on the stretch. It can be seen that the use of guides is unnecessary to make the folds lie side by side.

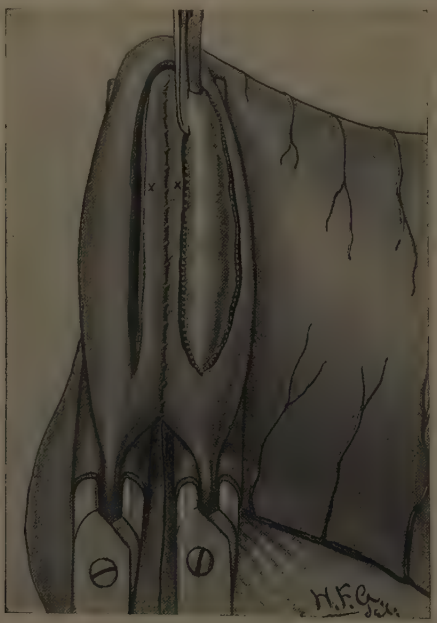

FIG. 481.—GOULD'S MODIFICATION OF FINNEY'S OPERATION.

Clamps now side by side. Folds approximated by a continuous seromuscular stitch. Stomach incision to mucous membrane; duodenum then opened freely to pyloric angle. Scissors now cutting out redundant mucous membrane at dotted line. The next step is to sew x to x, beginning at the pyloric end of the tongue.

dilated or has descended to an unusual extent the lower limit of the new outlet is at or near the level of its most dependent portion.

When the stomach is much dilated there is no contra-indication in this operation to the performance at the same time of gastropexy or gastroplication, if one considers them indicated.

W. J. Mayo[103] has performed 58 of these operations, with 54 recoveries, a mortality of 6.89 per cent., and of those that recovered 2 required secondary operation.

Munro, of Boston, says that the operation has not given him good results and that he has abandoned it. Last year Finney reported that he had performed his operation 25 times, with a mortality of 3 per cent., and that he had collected 112 cases, with a mortality of 9 per cent.

Gould, of Boston,[105] describes a modification of the operation which

FIG. 482.—GOULD'S MODIFICATION OF FINNEY'S OPERATION.

Tongue now closed over by continuous stitch which has turned corner to finish front of suture, bringing x to x; (*T*) sewed over tongue. The line of suture is finally buried by a seromuscular stitch.

seems to present certain advantages (see Figs. 480–482). The modification consists in the use of clamps, the trimming of the mucous membrane, the omission of guide stitches, and the use of continuous sutures.

Sinclair White[106] speaks favorably of Finney's operation; of the 5 cases on which he operated, 2 recovered and the after-results were good up to the time of his paper.

On the whole, it will be seen that the operation is only available in selected cases and the results show that the risk is considerably greater in Finney's operation than in gastrojejunostomy, while the after-history of those that recover is not so satisfactory.

W. J. Mayo[103] says: "Subjects for this operation should be carefully selected; extensive disease, adhesions, a short gastrohepatic omentum, and especially the presence of scar tissue should be considered contra-indications, as it is just these varieties in which gastrojejunostomy gives the most satisfactory results."

CANCER OF THE STOMACH.

Primary cancer of the stomach may be of the cylindric, spheroid, or, very rarely, of the squamous type (Rolleston[108]). If the stroma be abundant the term scirrhus is applied, and if scanty the cancer is spoken of as medullary. Fenwick, out of 115 cases, found 63.5 per cent. of the spheroid type, 28.6 per cent. of the cylindric type, and 7.8 per cent. in which the growth was undergoing colloid degeneration. Of 41 cases of spheroid-celled carcinoma 22 were of the soft or medullary and 19 of the scirrhous variety.

With regard to ulceration, metastasis, and secondary growths there is no striking difference between the two varieties of the disease, and either may take on a colloid form.

Dowd[109] called attention to the fact that according to the census reports there were 9000 deaths from cancer of the stomach in the United States in 1900, and of these very few had been submitted to surgical treatment.

An analysis of 1796 cases compiled from various authors showed the pylorus to be affected in 1110, the lesser curvature in 197, the cardiac orifice in 158, and the rest of the stomach in 331 (Furnival).

Extension of growth is usually through the lymphatics, but may be by continuity, through adhesions, through the blood-vessels, or by direct implantation on a neighboring surface through contact.

Through the Lymphatics.—To Cunéo, in his masterly *Thesis*, the profession is indebted for the excellent description of the lymphatic system of the stomach, which is well shown in Fig. 483, taken from his work. The lymphatics, as will be seen, drain into the glands along the lesser curvature as well as into those along the greater curvature, especially toward the pyloric end and in the adjoining portion of the great omentum, as well as into the glands in the neighborhood of the head of the pancreas.

By Continuity.—Cancer always extends beyond the area of induration, for while the limit of induration may be the diseased mucosa, the submucosa may be involved in growth for some distance beyond, and only scattered groups of cells yielding no evidence to the touch can be discovered on microscopic examination. It follows, therefore, that any effort at extirpation must go fully 1 inch beyond the margins of the tumor.

Extension through Adhesions.—In a very large proportion of cases adhesions are found at the time of operation between a cancerous tumor of the stomach and adjoining organs, especially the liver and biliary passages. This not only adds to the difficulty of the operation,

but also tends to invasion of the neighboring organs by continuity. These adhesions are due either to local inflammation set up by the growth or to extension of the malignant neoplasm. Gussenbauer and Winiwarter state that adhesions are found in 63 per cent. of cases of pyloric cancer, a statement which my personal experience on the operating-table would lead me to believe is even below the mark.

When the pylorus is affected extension takes place rapidly along the lesser curvature, the lymphatics and the adjoining glands becoming

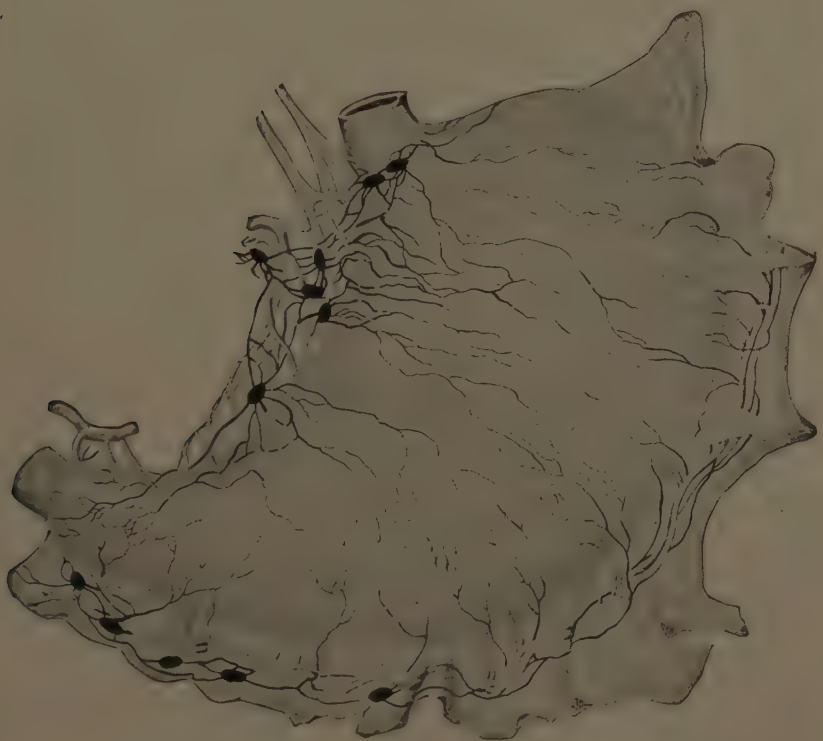

FIG. 483.—THE LYMPHATICS OF THE STOMACH. (Moynihan, after Cunéo.)

involved as far as the point where the coronary artery joins the stomach, at which place the lymph-channels pass from the lesser curvature. The reason of almost constant extension in this direction is that this is the chief course along which the lymph-stream travels from the stomach. In consequence of this early extension a mere excision of the pylorus for cancer is, as a rule, useless, since to get beyond the disease it is necessary to remove a considerable portion of the lesser curvature with its adherent lymph-vessels and glands.

The lymph-nodes on the greater curvature do not usually extend further to the left than a point near the middle. The dome of the stomach is almost devoid of lymph-vessels, hence in extensive gastrec-

tomy this part of the organ can frequently be safely left to form part of the future stomach.

Cunéo observed that pyloric growth frequently spares the duodenum, hence when a tumor extends well into it from the pylorus the chances are that it may be inflammatory swelling around an ulcer. This fact has on several occasions enabled me to rest satisfied with a gastro-enterostomy, when otherwise I should have performed a partial gastrectomy. The rule is, however, not absolute, as the neoplasm does at times extend through the pylorus well into the duodenum.

Extension through the blood-vessels is much commoner in sarcoma than in cancer of the stomach, but there are many examples of metastasis to the lungs, brain, and other organs in true gastric carcinoma that can only be accounted for by extension through the vessels.

Extension through contact is seen when the abdominal wall opposite to a fungating growth in the stomach becomes involved, and when the various tissues and organs forming the stomach bed become invaded without there being any direct channel either through the lymphatics or blood-vessels to account for the extension.

Cancer Incidence.—Age.—Cancer of the stomach may occur at any period of life from early infancy up to extreme old age, but it is most frequently met with from forty to seventy. In the census reports for 1890 the death-rate from cancer of the stomach was 10.24 per 100,000 living in the registration area. On analysis this yielded 3.22 between the ages of fifteen and forty-five; 34.45 between forty-five and sixty-five, and 79.96 over sixty-five years.[110]

Race.—The white races seem more predisposed to cancer than the black; Osler gives the actual incidence as 6 whites to 1 colored.

Sex.—The various estimates of the relative frequency of cancer of the stomach in the two sexes show that it is decidedly more frequent in males than females. Osler gives it as 5.2 to 1; Brinton, 2 to 1; Reiche, 1.8 to 1; my own experience in 110 operations on the stomach for cancer has differed considerably in hospital and in private. Of 55 hospital patients, 30 were males and 25 females=1.2 males to 1 female. Of 54 private patients, 44 were male to 10 female=4.4 males to 1 female.

Precancerous Conditions of the Stomach.—Precancerous conditions of the stomach are in certain cases distinctly recognizable, and if diagnosed and treated might save many patients from carcinoma. As the stomach is one of the commonest sites of cancer, if even a percentage of cases can be saved from malignant disease by timely treatment a great advantage will have been gained.

Ulcus Carcinomatosum.—The question of the cancerous transformation of an ulcer of the stomach was first discussed by Cruveilhier in 1839. Rokitansky, in 1840, also recognized the difference between chronic ulcer and cancer, and said that the latter might be implanted upon the former. To Dittrich, writing in 1848, belongs the chief credit for drawing attention to the subject.

Brinton, in 1856, recognized the possibility of the grafting of cancer

upon long-standing ulcer. Lebert, in 1878, considered that the cancerous transformation occurred in 9 per cent. of ulcers; but Zenker, in 1882, expressed a strong opinion that all cases of cancer of the stomach were secondary to ulceration. He called attention for the first time to the persistence of free HCl in the stomach contents in cases of cancer grafted upon ulcer.

In 1889, Rosenhein found in 46 cases of cancer 4 in which the malignant change was secondary to ulceration. In all these free HCl was present. Fuetterer, in 1902, made an extensive research into the origin of carcinoma of the stomach from chronic round ulcer. His conclusions, briefly stated, were as follows: (1) If a carcinoma develops from a chronic ulcer of the stomach, this development occurs from those parts of the edges of the ulcer which are most exposed to mechanical irritation by the contents of the stomach. (2) In the pyloric region it is the lower pyloric margin of the ulcer which is most exposed to mechanical irritation and from which carcinoma develops, but other parts of the edges may be the ones involved when dilatation and adhesions have changed the position of the organ. (3) Development of carcinoma from ulcers of the stomach in the pyloric region occurs with great frequency, while such a development occurs less often in other parts of the stomach.

In 1903, Audistere recorded examples and made very careful examination of 4 personal cases. His conclusions are summed up as follows: (1) Simple ulcer of the stomach may be the starting-point of a cancerous growth, a condition which appears to be not infrequent. (2) This malignant degeneration, as a rule, affects chronic ulcers, especially in the prepyloric region. The change begins in the mucous membrane at the margin of the ulcer. (3) The transformed ulcer presents for a long time almost the same symptoms as a simple ulcer, but the diagnosis may be made by noting the persistence of symptoms, the resistance to treatment, the wasting, and the progressive anemia. The pain, as a rule, is more severe than in cases of simple ulcer. (4) In cases of cancer apparently primary the origin in an ulcer may be suspected if the pain is unusually severe and paroxysmal, if hyperchlorhydria is pronounced, or if hematemesis or perforation occurs. The prognosis is decidedly more grave, for the progress of cancer grafted upon ulcer is more rapid and bleeding or perforation is liable to occur.

If these conclusions are correct, and my experience tells me they are, it is quite clear that in all cases in which an ulcer of the stomach resists treatment or its scar narrows the pylorus, we must recommend an early gastro-enterostomy or excision of the ulcer in order to prevent the development of carcinoma. If a gastro-enterostomy has been performed, then the mechanical irritation by food of the ulcer in the pyloric region is reduced, and the friction necessary to produce a carcinoma will probably not occur.

The estimates of the frequency of this malignant implantation upon a chronic ulcer vary greatly. The number of carcinomata beginning

in chronic ulcer is reckoned at 3 per cent. by Fenwick, Plange, and Berthold; 4 per cent. by Wollmans; 6 per cent. by Rosenheim and Hauser; 9 per cent. by Lebert; and 14 per cent. by Sonicksen. Zenker, as already mentioned, believes that all or almost all carcinomata are secondary to ulcer. Mayo, in 157 cases of cancer of the stomach, found a previous history of ulcer in 60 per cent. In no less than 59.3 per cent. of cases of cancer of the stomach on which I have performed gastro-enterostomy for the relief of symptoms, the disease having advanced too far for gastrectomy, the long history of painful dyspepsia suggested the possibility of ulcer preceding the onset of malignant disease.

Symptoms.—Since cancer, *per se*, has no symptoms, it not infrequently happens that if the growth involves the body of the stomach and the orifices it may pursue its complete course without giving rise to not any definite local symptoms, and it has not infrequently happened that the cause has only been discovered at autopsy. This form of latent cancer constitutes 5 per cent. of all cases according to Osler, who also gives it as his opinion that 10 per cent. of all cases of cancer of the stomach run an extremely rapid course, terminating in death within three months.

In the ordinary course the symptoms commence with loss of appetite and want of vigor, often coming on suddenly and without any apparent cause; loss of flesh is soon noticed, with pallor and shortness of breath; discomfort after food is usually felt, which may pass on to pain and a feeling of sickness and, after a time, vomiting of food. At first the vomit is usually free from blood, but in the later stages, when the cancer begins to ulcerate, it is signalled by coffee-ground vomit. Blood is rarely vomited in quantity, and only very rarely does hematemesis assume a serious form in gastric carcinoma, though I have known it to directly cause death on two occasions. Pyrosis is frequently complained of in the early stages of the disease. The bowels are usually constipated. After a longer or shorter interval, weeks or may be months, a tumor may develop in the epigastrium, and then the symptoms are usually so well marked that no doubt can be entertained as to the condition. Enlargement of the supraclavicular glands on the left side is an important sign indicating advanced disease.

On quite a number of occasions I have been consulted for abdominal tumor due to cancer of the stomach without any of the characteristic signs except general failure of health and loss of flesh, but in such cases the orifices of the stomach have not been involved in the growth. In the later stages profound anemia, edema of the limbs, ascites, and increasing weakness herald the end.

If the disease is at the cardiac end of the stomach, involving the cardiac orifice, the symptoms may resemble those of stricture of the esophagus and be associated with dysphagia, ending in an inability to swallow at first solid and later even fluid nourishment; in such cases the tumor, being well under cover of the ribs, is difficult or impossible to palpate, but enlargement of the supraclavicular glands on the left side is usually present.

If the pylorus be the part involved, dilatation of the stomach with retention and decomposition of food and vomiting are pronounced symptoms, the vomiting being at first irregular, perhaps every second or third day, soon becoming daily, and later occurring after every meal.

Visible peristalsis is not usually so marked as when the dilatation is due to simple stenosis, but it may be a prominent sign, and is then usually associated with pain that is relieved by vomiting.

If the disease attacks the center of the stomach it may lead to hour-glass distortion, with visible peristalsis of the proximal portion.

In some cases the neoplasm invades adjoining organs, as the pancreas, transverse colon, gall-bladder, bile-ducts, and liver, producing characteristic symptoms, such as jaundice and intestinal obstruction.

The special symptoms—pain, vomiting, and tumor—may be considered more in detail.

Pain is very variable and may be entirely absent throughout the course of the disease, or there may be discomfort and fulness after food, not amounting to actual pain. These painless cases Brinton gives as 8 per cent., Lebert as 25 per cent., and Osler as 13.3 per cent. In the majority of cases, however, from 80 to 90 per cent., pain is a prominent symptom. It may be continuous, with exacerbations after food, or may only be felt after meals, especially after solids have been taken.

When the pylorus is involved, leading to stenosis, peristalsis is usually accompanied by severe pain of a crampy character which is relieved by vomiting. The pain is usually referred to the epigastrium, occasionally passing through to the back, especially in the left subscapular region or even being only felt there. As a rule tenderness is absent, the disease then presenting a great contrast to gastric ulceration.

Vomiting occurs in 85 per cent. of cases of cancer of the stomach; it is usually a later symptom than pain. If the stomach is dilated the vomit may be large in quantity every second or third day, and I have seen material vomited that had been taken three or four weeks previously; the vomit may be offensive and fermenting, more so than is generally seen in ordinary cases of dilated stomach. If the stomach is small, vomiting usually occurs oftener and in smaller quantity; but when the disease involves the cardiac orifice there is regurgitation of food, but no actual vomiting.

Blood is vomited in about one-half the cases in my experience, though Osler only gives a percentage of 28.1. It may be bright in color and very profuse, though it is usually dark, like coffee-grounds.

Fever of a hectic type is present in about one-half the cases; it is, however, irregular, and may be absent or the temperature may even be subnormal throughout.

Tumor is discoverable in about 80 per cent. of all cancers of the stomach, and it is most unfortunate for radical treatment that in such a large proportion of cases this sign should be waited for before the

diagnosis is made and surgical treatment sought, for tumor is, as a rule, a late manifestation and usually affords evidence that the disease is no longer local.

Though the presence of a tumor makes it probable that in case of removal of the growth there will be recurrence, yet the rule is not without exception; as in my own experience I have a patient living and well seven years, another six years, and others at lesser periods after gastrectomy where tumors were perceptible before operation. Kocher and other surgeons have had similar experience.

We should make our diagnosis (if needful, by an exploratory operation) before a tumor can be felt if we want to obtain the best results from the surgical treatment of gastric carcinoma.

Inspection will often reveal a tumor if present, and in more than one-half of the cases I have seen the tumor has been seen visibly moving up and down during respiration. After manipulation, inspection will frequently reveal visible peristalsis in a stomach dilated from obstruction at the pylorus or in the proximal portion of a cancerous hour-glass stomach.

Palpation is of service, not only in discovering a tumor, but in estimating its mobility in a vertical or transverse direction and in helping to form some idea as to the possibility of removal; a tumor that is freely movable during respiration or under manipulation may, however, be too fixed for successful removal.

A malignant tumor is, as a rule, nodular and irregular, but it may be smooth; it is usually devoid of tenderness and, unlike inflammatory swelling, there is generally an absence of rigidity of the muscles overlying it.

Much information as to the position and size of the tumor may be obtained by palpating the abdomen with the stomach artificially inflated by carbonic-acid gas, and again by examining it when it has been emptied.

Although tumors of the stomach usually occupy the epigastrium, they may be found in any part of the abdomen, even in the pelvis. I have removed a pyloric tumor that could only be just felt beneath the left costal margin, and have also removed one that I could easily manipulate into every region of the abdomen.

A tumor may be formed by an atrophic cancerous stomach (leather-bottle stomach), in which the walls are thickened by cancerous infiltration and the lumen much diminished (Fig. 484).

This condition may be simulated by cirrhosis of the stomach, but the history is much longer in cirrhosis, though otherwise the symptoms may be almost identical. (See Gastric Linitis.)

In 54 per cent. of cases the tumor is at the pylorus, in 16 per cent. on the lesser curvature, in 9 per cent. at the cardiac end, in 3 per cent. on the anterior wall, in 4 per cent. on the posterior wall, in 4 per cent. on both walls, in 4 per cent. on the greater curvature, and in 6 per cent. it is diffuse (Lebert).

Enlargement of the supraclavicular glands on the left side is important

positive evidence of cancer of the stomach, and the sign may be present when a tumor is not to be felt; but the absence of this sign, as pointed out by Riegel, has no value as negative evidence. Rarely the left axillary glands are enlarged and left inguinal glandular enlargement has value as a positive sign.

Ascites is sometimes present, but it is usually a late sign, and is associated with diffusion of the growth to the peritoneum and to other organs.

Perforation of the stomach from cancer is not a very rare complication. Brinton gives it as 3½ per cent., Osler says 4 per cent. In cancer the perforation usually occurs slowly and leads to a local abscess, very rarely to acute perforative peritonitis, though I have seen a perforating carcinoma presenting symptoms as acute as those of perforating peptic ulcer.

Metastasis along the round ligament extending to the umbilicus was noted by Wickham Legg and has since been frequently observed;

FIG. 484.—EXTREMELY SMALL STOMACH DEPENDENT ON NEOPLASM—"LEATHER-BOTTLE STOMACH." (No. 2408, Royal College of Surgeons' Museum.)

I have seen it several times in late cases and have found it several times at operation undertaken at a time when it was hoped the disease might prove to be removable. It shows itself in the late condition as a hard cord extending to and involving the umbilicus. This sign may be present when no tumor can be felt.

Jaundice may be due to direct invasion of the bile-ducts or to secondary nodules in the liver; it is usually a late and always a very serious sign.

Interstitial pancreatitis, as shown by Cammidge's reaction in the urine and the presence of fat and muscle fibers in the feces, may occur early in the disease if the growth becomes adherent to the pancreas, but before it has extended into that organ; but when the pancreas has become invaded by the growth, the symptoms become exaggerated and the crystals obtained from the urine by Cammidge's reaction take two to five minutes to dissolve in dilute sulphuric acid instead of one-half a minute.

If the pancreatic duct is involved, the feces, which are normally alkaline, become acid and the constipation usually present may give place to bulky pale motions with a tendency to diarrhea.

The Character of the Vomit or of the Stomach Contents.—If the patient vomits, the vomited matter can be examined, but in the absence of vomiting, lavage of the stomach should be performed an hour after an Ewald's test-meal. Before coming to a definite decision it is desirable that the analysis should be repeated several times.

The absence of free HCl is in favor of cancer, as is the presence of lactic acid, but the presence of some free HCl and the absence of lactic acid have no negative value. In gastric carcinoma there is seldom found a normal amount of free HCl and never an excess except in ulcus carcinomatosum; the presence of an excess of free HCl is, therefore, decidedly in favor of ulcer. In 90 per cent. of cases of cancer collected from various sources by Osler there was an absence of free HCl in the stomach contents. In ulcus carcinomatosum, however, there is usually a large amount of free HCl in the stomach contents after a test-meal.

Digestive Properties of Stomach Contents.—This may be proved by testing the digestive power on albuminous foods of the fluid removed after a test-meal, or by Schwarz's method of examining by the Roentgen rays after the patient has swallowed a bolus of bismuth wrapped in an envelop of connective tissue obtained from the appendix vermiformis of a sheep.

Microscopic Examination.—The presence of new growth in the vomit or in the fluid removed by lavage is, of course, of prime importance, but it can only rarely be found, and it is quite unjustifiable to attempt to obtain it by mechanical means, such as scraping or brushing away portions from the gastric wall.

The discovery of the Oppler-Boas bacillus, a long, non-motile bacillus of the shape of a base-ball bat, is said by various authorities to be an indication of carcinoma, but while its presence is presumptive evidence in favor of carcinoma, its absence has no negative value. This bacillus is usually found when lactic acid is present in the lavage.

The presence of yeast-cells and sarcinæ is common to dilatation of the stomach with retention, both in simple and in malignant disease.

The discovery of blood-cells may be due to ulcer or cancer; it is, therefore, simply a sign of serious organic disease.

The *motor functions* of the stomach are best tested by examination of the stomach after a test-meal; such impairment may be due to pyloric stenosis from any cause or due to cancer of the body of the stomach or even to chronic gastritis, but in neurosis the mobility of the stomach is increased.

Diagnosis.—In advanced carcinoma there is usually little difficulty in making a diagnosis, the only mistake that would be likely to occur being either the mistaking of an inflammatory tumor associated with ulceration or the mistaking of a syphilitic tumor for a malignant growth. In the latter case the history and the result of specific treatment afford

clues to the diagnosis. In the former, induration around an ulcer, the long history, the tenderness on manipulation, and the presence of free HCl in the vomit or in the lavage should be of assistance; but all surgeons who have had any experience must have found a difficulty at times in deciding on a diagnosis between inflammatory disease and new growth, even when the abdomen is opened.

In several patients on whom I have operated for large growths at the pylorus or in the body of the stomach with extensive adhesions rendering removal impossible, and with enlargement of the glands rendering malignant disease extremely probable, I have performed gastro-enterostomy with the idea of giving relief; yet ultimately complete and perfect recovery has occurred and the patients were living and well years later, showing that the supposed cancer was evidently only inflammatory thickening around an ulcer which was cured by setting the parts at rest.

The presence of numerous adhesions, the discrete character of the enlarged glands which are softer than cancerous ones, the absence of secondary deposits in the viscera, and the absence of fungating growths in the tumor itself, are, when taken with the above-mentioned points, in favor of simple tumor; but, as acknowledged by Osler, Halsted, Finney, and many others, it is impossible in some cases without a microscopic examination to distinguish between simple inflammatory tumor and cancer. Fortunately, operation is of service in both conditions, therefore no harm but only good should result from the performance of gastro-enterostomy in either disease; and even if the pylorus be removed for chronic ulcer, thinking it to be cancer, and a new healthy passage into the bowel be established, the patient should be the gainer.

Hypertrophic stenosis of the pylorus is comparatively rare at the age in which cancer is usually found, and it has only once happened to me to mistake this condition for a neoplasm, the pylorus forming a perceptible tumor. Boas[5] has called attention to 3 cases of this kind in which the irritation gave rise to mistaken diagnosis. It is, however, in the early stages that errors in diagnosis are most likely to occur, leading to a fatal delay in cases which if diagnosed early can be cured by a radical operation; for it is undoubtedly proved that at first the disease is purely local and that its complete removal may be absolutely curative.

Treatment.—Medical treatment may be considered in a few words, it cannot cure, and can do very little even to prolong life; it, therefore, applies only to cases too advanced for surgical treatment or where operation is declined. It aims at nourishing the patient as much as possible and at relieving pain or other symptoms as they arise.

Surgical treatment offers the only chance of relief and the only possible chance of cure, and in order that the best results may be obtained, the physician and surgeon must act in concert, so that by a timely diagnosis an operation may be undertaken at the earliest possible date. There is ample evidence to show that for some length of time cancer is purely local; and just as in the breast, the tongue, and the

uterus we can point to patients living comfortable and happy lives years after the removal of the disease, so in gastric cancer it is reasonable to assume the same possibilities. Here, however, we are faced with the difficulty of a sufficiently early diagnosis being made, and it is not only necessary for us to appeal for an early, exhaustive, and persistent investigation into suspicious stomach cases, but that when the suspicions are confirmed an early surgical consultation may be held and, if needful, an exploratory operation carried out to complete the diagnosis. Whenever a patient at or after middle age complains somewhat suddenly of indefinite gastric uneasiness, pain and vomiting followed by progressive loss of weight and energy, and associated with anemia, the possibility of cancer of the stomach should be recognized, and in a suspected case, if no improvement takes place in a few weeks at most and if repeated examinations of the stomach contents after test-meals show diminished digestive power with a diminution or absence of free HCl and the presence of lactic acid, an exploratory operation is more than justified.

Let us remember also that to prolong the investigation uselessly and to wait until a tumor develops is to lose the favorable time for a radical operation; and although a clinical examination of the stomach contents and a general examination of the patient may give us strong grounds for suspicion, our diagnosis can only be rendered certain by a digital examination, which may be effected through a small incision which can, if needful, be made under cocain anesthesia with little if any risk.

At the time of the exploration it will be generally advisable to have everything ready to follow up the exploratory procedure by whatever further operation may be called for.

It would be easy for any one to raise a claim to having cured a number of cases of cancer of the stomach by gastro-enterostomy; but I do not for a moment believe that any of these cases were more than inflammatory tumors formed around chronic gastric ulcers; nevertheless, I have no doubt that they would have proved fatal just as certainly as if they had been cancer had no operation been done.

Experience shows that even though a tumor be present, and even though it be probably too large for removal, it may be quite worth while advocating an exploration, to be followed by gastro-enterostomy if that be practicable, in the hope that the disease may prove to be wholly or partially inflammatory, which the physiologic rest secured by gastro-enterostomy will either cure or materially relieve.

To pass to the genuine cancer cases, what can we do for them when diagnosed at an early stage? This will depend—

(1) On the position of the growth; (2) on its extent; (3) on the presence of adhesions; and (4) on glandular invasion or secondary growths.

First, as to position. In irremovable growth at the cardiac end, if it involve the cardiac orifice and adjacent portion of the stomach, gastrostomy or jejunostomy should be performed in order that starva-

tion may be staved off. The view that gastrostomy is both a dangerous and useless operation is, I know, held by some, but I feel convinced that such views are wrong. When these cases, either of cancer of the cardiac end of the stomach or of the esophagus, were handed over to the surgeon in a moribund condition the mortality of gastrostomy was, of course, terrible; and the short survival of the cases, even if successful from an operative point of view, made the procedure almost useless; but when one can point to a series of gastrostomies performed since 1897 with only a 5 per cent. mortality and with great prolongation of life in many and alleviation of suffering to all, I feel there are grounds for saying that the operation is well worth doing. The operation is quite a simple one, and if necessary can be performed under cocain anesthesia in a very short time. In several cases the patients have lived a year or more and have gained considerably in weight, even up to 20 pounds, and have lost their pain and the distressing sense of starvation.

The next class of cases is that in which the disease is even more extensive, involving a great part or the whole of the stomach, the disease being irremovable and gastro-enterostomy impracticable, and in which any attempt at taking food brings on pain and vomiting, so that the patient unless relieved must quickly die in great distress. Here a jejunostomy can be performed by a very simple and similar procedure to that of gastrostomy, and through a catheter sufficient food can be given to ward off starvation and relieve the pain caused by attempts at taking food by the mouth. This operation can be done through a small exploratory incision and need involve very little longer time. It may prolong life for months or even for a year and make the end much easier and certainly less painful. I reported a case of jejunostomy in 1891 in which the patient lived three months, and in 1904 one that had lived twelve months after jejunostomy, and the fact of my case of almost complete gastrectomy being well five years after operation shows that the passage of food direct into the small intestine may be compatible with comfort. Although the operation is rarely called for, it is one, nevertheless, which should be borne in mind, as in appropriate cases it may confer a great boon and render tolerable an otherwise comfortless existence.

The third class of cases to be considered is where the disease involves the pylorus and is producing obstruction to the passage onward of the gastric contents, but where, on account of the extreme feebleness of the patient or because of extensive adhesions, secondary growths, or involvement of glands, it is considered unwise to attempt pylorectomy or partial gastrectomy, though there is sufficient free stomach wall left to enable a gastro-enterostomy to be performed. In such cases a gastro-enterostomy, if performed with proper expedition and adequate precautions, affords the greatest relief to the sufferer, who not only loses the distress due to painful peristalsis and to the irritation of retained secretion, but also becomes freed from the toxemia due to absorption of the poisonous fermenting stomach contents. In some cases, where

the condition of the patient and not simply the extent of the growth has prevented a radical operation, the speedy restoration to health enables a radical operation to be subsequently undertaken.

The operation can be done with little risk, as including all my cases of posterior gastro-enterostomy performed during the past ten years the mortality is only 3.3 per cent., a great contrast to the death-rate of these cases a few years ago.

The remaining class of cases is of great interest, and includes those where the disease is limited to the stomach, and where the lymphatic glands and adjoining organs have not been seriously invaded, the patient being in a sufficiently good condition to permit of the radical operation being done.

The removal of even a considerable portion of the stomach may be something more than a palliative operation, and I think it justifies me in saying that although it is better to have cases of cancer diagnosed and operated on early, yet we need not take the pessimistic view, which has been given by some surgeons, that if a tumor be manifest it is too late to perform a radical operation.

In conclusion, I hope I have advanced sufficient evidence to prove: (1) How desirable it is to make an early diagnosis of cancer of the stomach in order that a radical operation may be performed at the earliest possible moment. (2) That it may be needful to perform an exploratory operation in order to complete or confirm the diagnosis. (3) That such an exploration may be done with little or no risk in the early stages of the disease. (4) That even where the disease is more advanced and a tumor perceptible, an exploratory operation is, as a rule, still advisable in order to carry out radical or palliative treatment. (5) That where the disease is too extensive for any radical operation to be done, the palliative operation of gastro-enterostomy, which can be done with very small risk, may considerably prolong life and make the remainder of it much more comfortable and happy. (6) That some cases, thought at the time to be cancer too extensive for removal, may, after gastro-enterostomy, clear up completely and get quite well. (7) That in cases of disease of the cardiac end of the stomach too extensive for removal the operation of gastrostomy may considerably prolong life and prove of great comfort to the patient by preventing death from starvation. (8) That even where the disease is too extensive either for removal or for a gastro-enterostomy or even a gastrostomy being performed with a fair chance of success, the operation of jejunostomy may prove of service to the patient. (9) That where a radical operation can be performed, the thorough removal of the disease may bring about as much relief to the patient as does the operation for removal of cancer of the breast, uterus, and other organs of the body, and that in some cases a complete cure may follow.

SARCOMA OF THE STOMACH.

Primary gastric sarcoma is not so rare as it is generally thought to be. It is probable that a number of cases described as cancer have

been true sarcomata, from the fact that a number of museum specimens classed as cancer on microscopic examination have proved to be sarcoma.

Fenwick [114] stated in November, 1900, that out of 60 recorded cases, 53 at least ought to be regarded as genuine, and he thought that they constituted from 5 to 8 per cent. of all primary neoplasms of the stomach.

The recognized varieties are round-celled and spindle-celled sarcoma, myosarcoma, and angiosarcoma.

Round-celled sarcoma constitutes 62 per cent. of all the recorded cases. It occurs, as a rule, as a dense infiltration of the pyloric third of the stomach and, unlike cancer, tends to render the pylorus patulous, though in some cases the thickening leads to partial stenosis. In about one-sixth of the cases the growth involves the entire stomach, invading both esophagus and duodenum. The mucous membrane presents signs of chronic inflammation and ulceration. In only 2 of Fenwick's cases was there a circumscribed tumor with secondary nodules in the surrounding mucous membrane. In a case of round-celled sarcoma Schopf [116] removed a tumor the size of a child's head, leaving the cardiac and pyloric ends of the stomach, which he sutured together. The patient was alive twelve months later.

Spindle-celled sarcoma constituted 22 per cent. of the 53 cases. It presents itself usually as a round or circumscribed tumor in the neighborhood of the greater curvature and tends to project toward the serous coat, ultimately forming a very large tumor, sometimes becoming pedunculated. The size attained may be so enormous as to fill the whole of the abdomen.

Billroth successfully removed a cystic sarcoma of this variety. Cantwell [117] removed one weighing 12 pounds, but it recurred eight months later.

Myosarcoma.—Of the 53 recorded cases, 5 were of this variety. They form smooth or slightly nodular tumors and usually occur near the greater curvature. They may attain an enormous size, Brodowski having met with one of 12 pounds.

Angiosarcoma.—Two cases have been recorded; in one case the tumor was the size of a child's head. It contained many cysts due to hemorrhage. Kosinski [118] successfully removed a tumor of this kind.

Symptoms.—Sarcoma of the stomach may occur at any time of life, from infancy to extreme old age. The symptoms are similar to those of carcinoma—progressive loss of flesh with debility and anemia. Pain is usually present. Pyrexia slight, but persistent, and albumin in the urine may be present. Hematemesis is apt to occur and may be so free as to cause death. Free HCl is usually absent and lactic acid present as in cancer. The small round-celled sarcoma resembles cancer in all respects, except in less frequently leading to stenosis; but in spindle-celled sarcoma gastric symptoms may be entirely absent and when operative treatment is undertaken in a rapidly growing tumor the growth may be discovered unexpectedly to arise from the stomach. Perforation is apt to occur in round-celled sarcoma in from 10 to 12 per

cent. of all cases. Metastases in glands, distant organs, and especially in the skin are prone to occur. According to Kundrat, the tonsils are apt to enlarge and the follicles on the side of the tongue to become swollen and ulcerated.

The prognosis varies with the nature of the growth; in round-celled sarcoma the average duration of life is fifteen months; in spindle-celled sarcoma and myosarcoma the average is two years and eight months.

Treatment.—Surgical treatment of gastric sarcoma has met with considerable success, so far as the immediate effect of operation is concerned. The solid tumors are especially favorable for extirpation, particularly when pedunculated, but in all cases it is desirable to remove the portion of stomach wall from which they spring.

In the round-celled variety a wide removal of the stomach by partial or complete gastrectomy is required in order to give any hope of success. Török, Dock, Schopf, and others have removed considerable tumors, and in Schopf's case the patient was living a year later. Early diagnosis and early thorough surgical treatment must be the great aims in the treatment of sarcoma.

Statistics.—Lecene and Petit[119] report 10 deaths out of 24 collected cases, but only 1 out of 7 proved fatal where the resection of the gastric walls was around a circumscribed tumor.

OPERATIONS FOR GASTRIC CANCER.

(1) Simple exploratory incision.
(2) Gastrectomy: (*a*) Partial. (*b*) Complete.
(3) Gastro-enterostomy.
(4) Gastrostomy.
(5) Jejunostomy.

Simple Exploratory Incision for Diagnostic Purposes.—This operation has already been described (see pp. 706 and 835).

If no disease of the stomach be found, the small incision can be securely closed and the patient may safely be allowed on the sofa within the week. If the disease is found to be too extensive for removal and no further operation be required, it is most desirable that the few remaining weeks of life should not be spent in bed, and if the aponeurosis and muscles are united by buried through-and-through silver sutures or by silk-worm gut sutures, and the wound covered with a collodion dressing, the patient may safely be allowed on the couch on the second or third day. The risks of an exploratory operation for diagnostic purposes in an early stage of disease are practically nil, and in efficient hands are only likely to occur from some accidental cause, such as pneumonia.

Krönlein had a mortality of 9.5 per cent. in 73 cases. Mikulicz had 4 deaths in 44 cases (9 per cent.), and the duration of life after operation averaged four and four-fifths months.

As these statistics include cases operated on several years back, it is needless to say they show a much higher rate of mortality than would

a corresponding number of cases operated on to-day. Arguing from my own cases the mortality, I think, should not exceed from 3 to 5 per cent. In the St. Mary's Hospital (Rochester, U. S. A.) report for 1905 the brothers Mayo record 25 exploratory operations for carcinoma without a death.

Gastrectomy.—Although so far back as 1810, Merrem, operating on a dog, showed the possibility of a successful removal of the pylorus, the operation was not performed on man until April 9, 1879, by Péan, the first successful operation being by Billroth on February 28, 1881.

It is now universally recognized that a radical operation for the complete and wide removal of the growth should be the aim of surgical treatment for cancer or sarcoma of the stomach.

For gastrectomy to be successful it is desirable that the operation should be undertaken at an early stage of the disease, before extensive adhesions have formed, before the lymphatics have been seriously invaded, and before secondary growths have developed.

The idea that it is too late to perform a radical operation when a perceptible tumor is present is exploded, as it is well known that many partial and even complete gastrectomies have led to successful issues in the presence of large tumors.

It should not be lost sight of that the presence of enlarged lymph-glands does not necessarily imply their cancerous invasion, as ulcers alone or the inflammation of a cancerous tumor without cancerous infiltration may cause glandular enlargement, as I have found on several occasions.

Firm adhesions to neighboring organs—liver, pancreas, gall-bladder, or colon—or to the parietes, as a rule, forbid a radical procedure, though in 1 of my cases the removal of the gall-bladder, a portion of the liver, and the pylorus, as well as a considerable area of parietal peritoneum and the overlying rectus muscle, was not only followed by recovery, but the patient is well six years later, the disease having been proved to be cancer by microscopic investigation.

If the tumor, though somewhat tied up by adhesion, is movable, even if adherent to the colon, it need not necessarily be given up as hopeless, as under such circumstances a number of successful partial gastrectomies, including partial colectomy, have been performed.

No good purpose will be served by a gastrectomy that does not remove the whole of the disease, as recurrence will be certain to occur and probably as much relief with a very much diminished risk would be given by a smaller operation.

Partial Gastrectomy of the Pyloric End of the Stomach.—I have not used the term pylorectomy, as the simple removal of the pylorus is only justifiable in non-malignant disease, such as chronic ulcer.

If the exploratory operation has shown the tumor to be a removable one involving the pyloric end of the stomach, the incision is extended up to the notch between the ensiform cartilage and the right costal margin and down to the level of the umbilicus or beyond it.

It will now afford some help if a small sand-bag be placed under the back opposite the lower ribs, as in that way the area of operation is brought close to the surface.

The lesser omentum is divided between two rows of interrupted catgut sutures applied by means of a curved blunt needle in a handle, the ligament being divided at a distance from the lesser curvature of the stomach so as to include the glands in the part to be removed. In order to save hemorrhage there is an advantage quite early in the operation in ligaturing in their continuity or catching in pressure forceps the four arteries with their accompanying veins supplying the pyloric end of the stomach; these are the gastric, best divided at a point about ¾ to 1 inch below the cardiac orifice where it joins the lesser curvature; the pyloric, just above the pylorus, shortly after it leaves the hepatic artery; the right gastro-epiploic or the gastroduodenal, as it passes down behind the pylorus, and the left gastro-epiploic, just below the greater curvature of the stomach at the point where the section of the stomach is to be made. It saves time and answers equally well to seize the four vascular trunks in pressure forceps, and when the excision of the stomach is done, to ligature them singly.

The fingers of the left hand are then passed into the lesser peritoneal sac and made to encircle the growth and to cause the great omentum to project forward, thus avoiding the transverse colic vessels, the ligature of which would endanger the vitality of the transverse colon. The great omentum is then ligatured and divided in the same way as the lesser, as wide a margin of omentum as possible being left attached to the part of the stomach to be removed. Double clamps are then applied to the duodenum and also to the stomach on the cardiac side of the growth, and between the clamps the duodenum is divided quite ½ inch on the distal side of the growth and the stomach 1 inch or more beyond the proximal side of it. The growth, which is then free, is lifted away, the clamps occluding the cut ends and preventing any of the contents soiling the wound.

A careful search must now be made for any glands that may have been missed and any such should be removed. Any bleeding vessels are ligatured and the wound is cleansed by dry aseptic swabs.

The junction of the stomach and duodenum may be carried out in one of several ways:

(1) By immediate suture of the open end of the duodenum to the open end of the stomach (Billroth). (Terminal union.)

(2) By closure of the stomach opening and implantation of the open end of the duodenum into the posterior surface of the stomach (Kocher). (Terminolateral union.)

(3) By closure of both the stomach and duodenal openings and the independent formation of a gastrojejunostomy (Billroth). (Lateral union.)

1. *By Immediate Suture of the Cut Ends.*—This method was advocated by Mikulicz and Krönlein. Although statistics seem to prove that it is attended with greater risk than the other methods, on account of the

fear of leakage at the critical angle between the vertical and circular sutures, I feel sure these difficulties and dangers can be overcome by the use of continuous sutures over a decalcified bone-bobbin. I have carried out the operation in a number of cases that have progressed most satisfactorily. The inequality in the size of the stomach opening is overcome by a partial closure of the stomach incision, so as to leave the opening of a size equal to that in the duodenum. The two openings may then be joined either by means of sutures or by sutures around a decalcified bone-bobbin, which forms a splint and ensures the opening being made of sufficient size. The bobbin is of the greatest possible advantage in this situation, as a large proportion of deaths that have occurred from simple suture have been due to a leakage at what has been termed "the fatal suture angle of Billroth," a danger which can be wholly avoided by its use.

Rutherford Morrison advocates the junction by simple suture, and in order to make the opening in the duodenum correspond in size with that in the stomach, he makes a slit ½ inch in length down the center of the anterior wall of the duodenum. By spreading out this longitudinal cut the duodenal opening is so widened that it may be made to correspond in size with the opening in the stomach.

The method of joining the cut ends by suture is the same whether the decalcified bone-bobbin is employed or not; the only difference is that at a certain stage the bobbin is introduced before the suture is continued around the anterior half of the circle.

The method is as follows: While the clamps are still in position a long chromic catgut suture is passed through all the coats of the cut stomach wall, beginning at the upper end. This is carried down until a point is reached which will leave the stomach opening of a size to correspond with that of the duodenum. At this stage the suture is passed beneath the last loop, so as to prevent its slipping. The needle is then temporarily laid aside, still threaded. The sutured edges are now inverted and a serous suture, which only transfixes the serous and muscular coat, is inserted, commencing at the point (*a*) and drawing together the serous surface as far as the place where the marginal suture was laid aside. The open ends of the two viscera are then placed in apposition and the serous suture is continued around the posterior half-circle, uniting the peritoneal coats of the duodenum and stomach about ¼ inch from the margins of the opening that is to be permanent between the stomach and bowel. The needle is then laid aside threaded, and the marginal catgut suture previously laid aside is now taken up and continued around the posterior part of the opening through all the coats of the two viscera, so as to make the mucous membranes continuous and at the same time to act as a hemostatic suture. After this has been carried around the posterior half circle, if the bobbin is employed it is now placed in position; but whether the bobbin is inserted or not the mucous suture is continued, taking up all the coats on the anterior part of the circle until it reaches the point (*b*), where it is secured by a knot and cut short. The serous suture is now taken up and continued round

to the same place, when it is also knotted and cut short. At the angle between the vertical and circular part of the suture there should be no point of danger and no tension if the stitching has been well done, but if there is any doubt it may be advisable to insert two or three separate serous sutures of Pagenstecher's thread in order to strengthen this point, which has been termed the angle of danger.

2. *Kocher's Method.*—Kocher, whose method has been carried out most successfully, not only by himself but also by many other surgeons, closes the cut end of the stomach by means of a continuous catgut marginal suture, taking up the whole thickness of the cut surfaces, including the mucous membrane, after which the united edges are invaginated and closed by a silk or Pagenstecher's thread for the serous surfaces. The open end of the duodenum is then applied to a new opening made in the posterior surface of the stomach, to which it is united. This part of the operation may be accomplished either by simple continuous sutures or by sutures around a decalcified bone-bobbin. The junction by suture or by suture around a decalcified bone-bobbin differs in no way from the method described under gastro-enterostomy, except that in this case the open end of the duodenum is applied to an incision in the back of the stomach, whereas in an ordinary gastro-enterostomy the openings are both into the sides of the viscera to be joined.

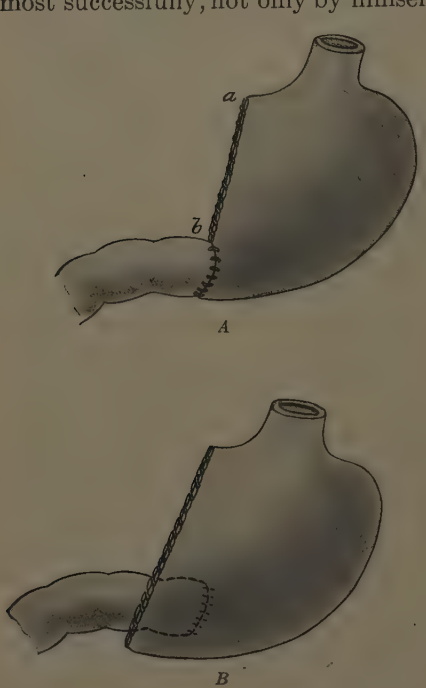

FIG. 485.—*A*, PARTIAL GASTRECTOMY. TERMINAL UNION. (Billroth.) *B*, PARTIAL GASTRECTOMY. TERMINOLATERAL UNION. (Kocher.)

In some cases it may be found easier to make the anastomosis through the front of the portion of stomach remaining instead of through the posterior wall.

3. *The Third Method.*—In it the open end of the duodenum and the open end of the stomach are closed by sutures and a loop of jejunum is united to the lower end of the cavity in the stomach. It may be performed either by the anterior or posterior method, and in no way differs from the ordinary operation of gastrojejunostomy. This operation may be performed with advantage in two stages where the patient is not in a very good condition and unable to bear the complete procedure. In such cases the gastrojejunostomy is first performed, the

bowel being united to the cardiac end of the stomach. From two to four weeks later, when the patient has gained more strength, the second or radical operation is performed, the disease being completely and widely excised and both cut ends being closed by sutures.

Partial Gastrectomy of the Body of the Stomach, as in Hour-glass Deformity.—This operation is practically the same as the partial gastrectomy of the pyloric end of the stomach, except that the clamps are placed on each side of the growth and the section of the stomach is made at a distance of not less than 1 inch away from the tumor on each side. Neither the pyloric nor cardiac orifices are interfered with, and the junction is made by a continuous serous suture of Pagenstecher's thread surrounding a continuous catgut suture embracing all the coats and bringing together the mucous surfaces. The vessels along the lesser and greater curvatures are caught in pressure forceps or are divided between two ligatures before applying the clamp.

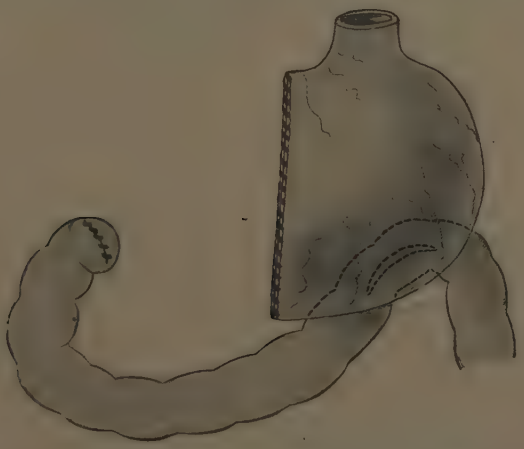

FIG. 486.—PARTIAL GASTRECTOMY. LATERAL UNION. BILLROTH'S METHOD.

Much has been written as to the best method of uniting the small intestine to the remains of the stomach in partial gastrectomy. My own feeling is that each case must be a law unto itself, for I have tried all three methods, and I believe that each can be done with equally good results in suitable cases. I feel sure that the end-to-end method can be more safely accomplished by suture over the decalcified bone-bobbin than by suture alone, but I think that, as a rule, the end-to-side method, known as Koche 's operation, will be found the most generally useful, and in Kocher's hands, as well as in the hands of other surgeons, the union of the divided end of the duodenum to a new opening in the posterior or anterior wall of the stomach, when a sufficient amount of duodenum is available, will be found to be the best of all procedures.

Complete Gastrectomy.—This formidable operation was first conceived and performed by Conner, of Cincinnati, in 1883. Unfortunately, the patient died on the table and it was not until fourteen years later

that the first successful complete gastrectomy was performed by Schlatter, of Zurich, on September 6, 1897, and the second by Brigham, of San Francisco, on February 24, 1898. In Schlatter's operation the cut end of the esophagus was united to the loop of jejunum, the duodenal

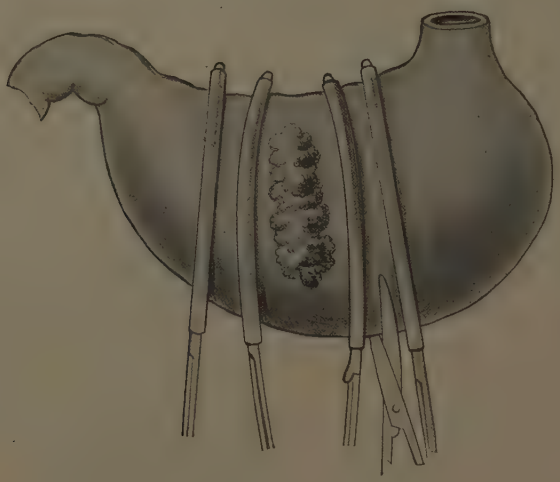

FIG. 487.—PARTIAL GASTRECTOMY OF BODY OF STOMACH.

opening being closed. In Brigham's operation the cut ends of the esophagus and duodenum were united over a Murphy button.

Up to October, 1905, 27 of these operations had been performed by various operators, and it is interesting to note that Paterson was able to

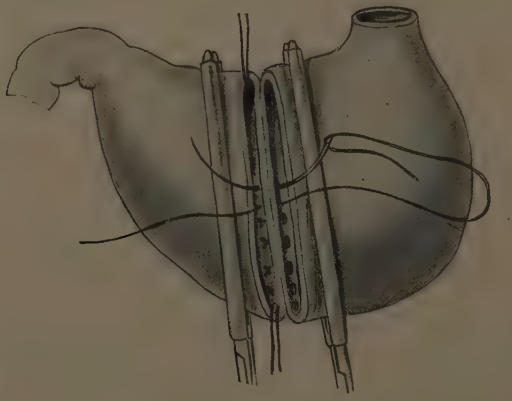

FIG. 488.—PARTIAL GASTRECTOMY OF BODY OF STOMACH.

obtain information that 10 of the patients are living and well eight years, seven years, five years, four years nine months, four years, three years six months, two years, and one year nine months respectively, and two others at lesser periods after operation; while others survived three

years nine months, one year nine months, thirteen months, nine months, and seven months respectively; death from operation having occurred in 10 cases; a remarkable series when the severity and extent of the operations are taken into consideration. The operation is merely an extension of that already described under partial gastrectomy, the clamp seizing the esophagus just above the stomach instead of the stomach itself. If the stomach be pulled gently downward the orifice may be made to protrude through the aperture in the diaphragm for a little distance, so as to leave room for the application of a clamp.

Although if a small portion of the dome of the stomach be left (subtotal gastrectomy), as was the case in one of my patients who is still living and well over five years later, the operation cannot then be called a complete gastrectomy, yet I have no hesitation in advising this modification in suitable cases, as it enables the junction between the intestine and esophagus to be made so much more easily. If, however, the operation of total gastrectomy is performed, the open end of the esophagus can be joined to the intestine by means of sutures, as in Schlatter's case; by the Murphy button, as in Brigham's case; or by means of the decalcified bone-bobbin, as in my own case, all of these patients having recovered.

Should it be found that an anastomosis between the esophagus and the intestine cannot be effected, the opening into the esophagus may be tightly clamped and ligatured in the groove made by the clamp, the mucous membrane beyond the ligature being taken away. The open end of the duodenum may then be closed and a jejunostomy performed by the method I have described on p. 942. This would be simpler and probably safer than performing a duodenostomy, as has been done in 1 recorded case.

In some of the published articles on gastrectomy arbitrary lines of incision of the stomach wall have been given; it seems to me that this is undesirable; the extent of the disease should be the chief guide, and in no case should the cardiac end of the stomach be divided nearer to the growth than from 1 to 2 inches.

As the chief course of the lymphatics is along the lesser curvature as far as the point where the gastric artery joins it, in any case of cancer of the pyloric end of the stomach the incision through the lesser curvature ought not to be more than 1 inch from the cardiac orifice. With due precaution little or no blood is lost and all soiling of the abdomen by stomach contents is avoided; drainage is, therefore, usually unnecessary and undesirable.

The clamps I use (Fig. 455) I have employed for many years for gastric and intestinal surgery; they are thin in the blade, so as not to exert unnecessary pressure, and I usually have them sheathed with India-rubber tubing, so that no damage to the visceral walls occurs.

The curved intestinal needles (Fig. 456) I use for all visceral suturing I have also employed since 1884, and with slight modification in size and thickness they have done me very good service. I never use a needle-holder.

The Results of Gastrectomy, Immediate and Remote.—Up to the end of 1905 Kocher had performed 110 partial resections of the stomach, with a mortality of 24 per cent., but in the cases (58 in number) operated on since 1898, the mortality had been only 15 per cent., a percentage closely corresponding to that of the brothers Mayo, who up to the end of last year had performed 100 gastrectomies with a mortality of 14 per cent. In my own practice, since 1896, the mortality for partial gastrectomy has been 13 per cent. and Maydl's statistics give a 16 per cent. mortality.

We may thus conclude that the immediate risks of partial gastrectomy, as calculated from a considerable series of cases, are between 14 and 16 per cent.

Of the 27 cases of total gastrectomy collected from all sources by Paterson, 10 died, a mortality of 36 per cent. Of the 20 cases of subtotal gastrectomy, 6 died, a mortality of 30 per cent.

The remote results are equally interesting and not less important, not only from the point of freedom from recurrence, but also as to the effect on the general health and comfort of the patient after the removal of the whole or part of the stomach. I have had under my notice for over five years a case of subtotal gastrectomy, and from observations on this case it would seem as if the whole of the functions of the stomach could be replaced.

It would at first sight appear that, as a reservoir, the stomach could not be replaced, but the fact that a meal of moderate size can be taken shows that the upper end of the duodenum or the lower end of the esophagus, or both, become dilated and serve that purpose, though perhaps to a limited extent. The mechanical functions of the stomach can be vicariously performed by the mouth and by a careful selection of diet. The digestive functions of the gastric juices can be taken up by the pancreatic and the intestinal secretions; and the absorption which normally occurs in the stomach can as easily take place in the small intestine.

Pachon and Carvalho have shown that dogs may gain in weight and remain in perfect health after removal of the entire stomach; further observations on patients after complete gastrectomy, as in Schlatter's case, show that perfect health is compatible with an absence of the stomach.

Of the 27 total gastrectomies, it is interesting to note that 10 are living and well eight years, seven years, five years, four years nine months, four years, three years six months, two years, and one year nine months, and two others at less periods after operation, while others survived three years nine months, one year nine months, thirteen months, nine months, and seven months respectively.

With regard to the subtotal gastrectomies, of the 14 patients who recovered from operation 1 was well seven years six months, 1 six years nine months, and 1 five years three months after operation, while of the others, 1 survived operation for eleven years and died of heart trouble without recurrence, 1 five years, 2 two years nine months, 2 one year nine months, and 1 one year six months, respectively.

The immediate results of partial gastrectomy have been mentioned above and the final history has been obtained by Paterson in 55 of those that recovered. Of the 55 patients, 35 have died since the operation, 1 died from recurrence seven years and 2 five years later, but it is interesting to note that all the other patients in whom recurrence ensued died within three years six months, so that if a patient remains free from recurrence for four or more years there would seem to be a strong probability of cure. Of the patients who died, 8 lived over three years after operation, and the average duration of life in cases where recurrence took place was just over two years. Of the patients who are apparently cured, 1 is alive and well fourteen years, 1 seven years six months, 2 six years, 1 five years, 2 four years, 5 over three years, and 3 over two years subsequent to operation, and 1 was living four years six months after operation, but recurrence was feared. Thus, nearly 14 per cent. of the patients who recovered from operation would seem to be cured or to have a reasonable prospect of remaining free from recurrence.

After a careful analysis of all the cases operated on I cannot help feeling that far too gloomy a view is taken of cancer of the stomach, for if the disease be caught early and a wide excision performed, care being taken to remove the lymphatic area of the stomach with the glands along the lesser curvature, results even better than those I have just mentioned will be obtained. Our great hope of success, I venture to state at the risk of being accused of reiteration, lies in early and complete removal.

Gastrostomy, by which an artificial opening is made in the stomach, through which a patient may be fed when for various reasons food cannot be taken in the ordinary way, was first suggested by Egeberg in 1837, but was first carried out by Sédillot in 1849. In 1875 Sydney Jones performed the operation and the patient survived sixteen days, but Verneuil, in 1876, had a patient to survive for sixteen months.

Survival after gastrostomy for cancer of the esophagus does not often exceed a few months. After the operation for simple stenosis life may, however, be prolonged for years; one of my patients is living seven years later, and I have heard of one surviving for ten years, all the food being taken through the artificial opening.

Indications.—(1) Cancer of esophagus or pharynx, causing obstruction to swallowing of food. (2) Simple stenosis of pharynx or esophagus, which cannot be kept patent by bougies. (3) Cancer of cardiac end of stomach, obstructing the entrance of food into the stomach. (4) It has been suggested as a palliative procedure in extensive cancer within the mouth or pharynx, in which, although swallowing of food is possible, it can only be accomplished with great pain.

The operation is most useful, but was for long held in disrepute for two reasons: First, from the custom of delaying gastrostomy until the patient was in the last stage of exhaustion, when naturally the mortality was very great; secondly, when a direct opening into the stomach used to be made, leakage of the stomach contents with consequent irritation of the skin around the fistula made the remainder of life, in

case of survival, so miserable that it was thought to be scarcely worth while to recommend it. With improved technic, however, the operation is rendered both safe and efficient.

Operation.—The operation I am accustomed to perform is very simple and only occupies a few minutes; if needful it can be done under local anesthesia.[1] It is a modification of the Ssabanajew-Franck operation and has given me 23 recoveries out of 24 operations.

A vertical incision of about 1½ inches is made over the outer third of the left rectus abdominis, commencing ¾ inch below the costal margin; the fibers of the rectus are separated, but not divided, and the posterior part of the rectus sheath and the peritoneum are divided together, the opening being 1 inch in length. A portion of the cardiac end of the stomach is then brought up through the wound and held forward by an

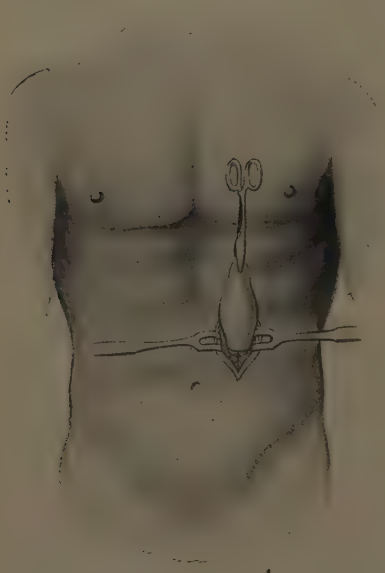

FIG. 489.—GASTROSTOMY. FRANCK'S METHOD, MODIFIED BY MAYO ROBSON.

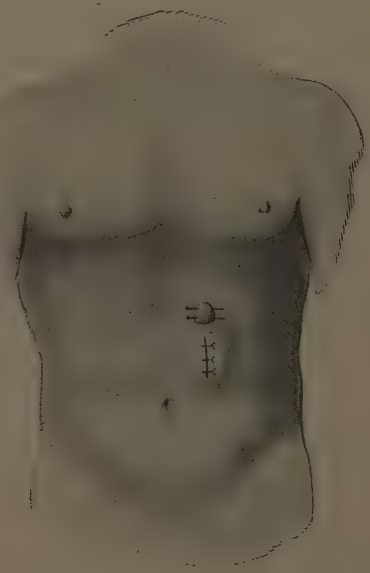

FIG. 490.—GASTROSTOMY. FRANCK'S METHOD, MODIFIED BY MAYO ROBSON.

assistant until four sutures are inserted into the base of the cone by means of a curved intestinal needle, so as to fix the visceral peritoneum of the stomach to the edges of the parietal peritoneum. A transverse incision of ½ inch is then made through the skin 1 inch above the upper end of the first cut, and by means of a blunt instrument, such as the handle of a scalpel, the skin is undermined so as to connect the two openings beneath the bridge of skin and subcutaneous tissue. A closed pair of pressure forceps is introduced through the upper incision, as far as the projecting part of the stomach, and grasps the apex of the gastric cone, which is drawn beyond the surface of the second opening, where it is retained by means of two harelip pins. It should just fill the opening and should require no sutures. The lower opening is now closed by two or three silkworm-gut sutures or by a continuous stitch, and the

edges are dried and covered with collodion and gauze. The stomach is opened at once by a tenotomy knife introduced between the pins. After opening the stomach a soft catheter (Nos. 8 to 12) is inserted, to which a piece of rubber tubing is fixed, and by means of a funnel the patient can be fed on the table with warm milk and egg, or whatever liquid may be thought desirable. The catheter may be left in position for a few days, after which it is easy to insert it whenever a meal is required.

E. J. Senn's Method.[122]—The stomach being exposed, an incision about 1 inch in length is made into its cavity as near the cardia as possible, and midway between the greater and lesser curvatures. A tube equal to a No. 12 or 14 catheter is now introduced into the stomach and there fixed by a suture, which includes the cut edge of the stomach and the side of the tube. In order to infold the tube in the stomach wall a purse-string suture is passed round the tube at a distance of ½ inch from

FIGS. 491 AND 492.—GASTROSTOMY. E. J. SENN'S METHOD.

it. The tube is pushed inward toward the stomach cavity while the suture is tied. A second purse-string suture and then a third are passed and tied in the same manner. The result is that the tube lies in a funnel-shaped inverted portion of the anterior wall of the stomach and is there fixed by the sutures placed one above the other. The stomach is now fixed to the anterior abdominal wall by a suture above and one below the tube, and the abdominal incision is closed in the usual manner. The advantage of this method over Franck's or its modification lies in the fact that, as the portion of the anterior stomach wall used for the purpose of effecting valvular action is pushed inward instead of being dragged outward, a larger cavity is left for the reception of food, and the area of the gastric mucosa brought into contact with the food is, therefore, more extensive. I can recommend this method as at once easy, safe, and efficient.

Witzel's Method.[123]—An incision, parallel to the costal margin, is made until the rectus muscle is reached. The fibers of the muscle are split

vertically and the peritoneum opened. The stomach is exposed and drawn out of the wound; a small incision is made into the stomach, a tube introduced, and fixed by a single catgut suture. The tube is then laid upon the stomach wall for a distance of 2 inches or rather more, and a gutter is made for it by raising up a fold on each side and stitching the folds over the tube. The stomach is fixed to the abdominal wall by two or three sutures. Mikulicz and Helferich have shown that after

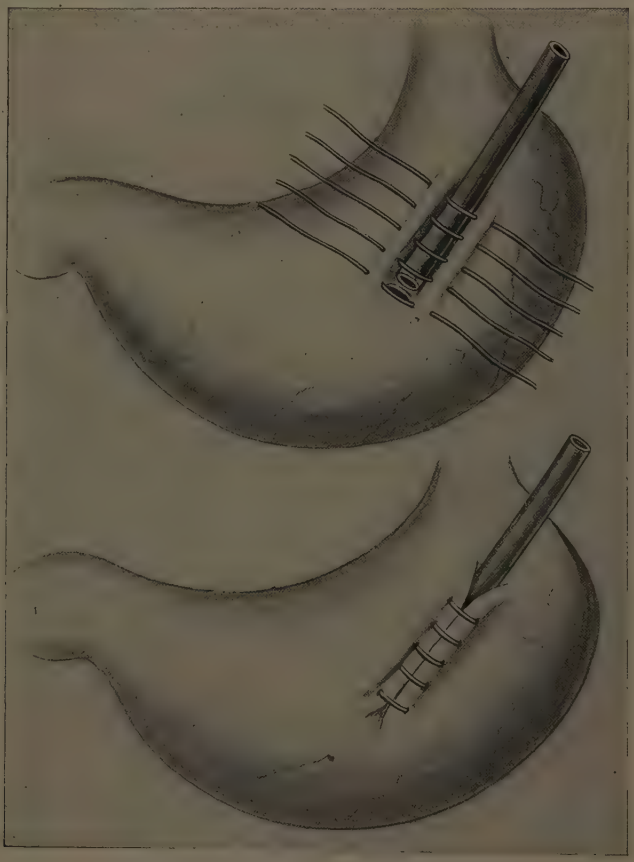

Fig. 493.—Gastrostomy. Witzel's Method.

the lapse of a few months the oblique passage for the tube becomes a direct one, the inner orifice lying behind the outer.

Kader's Method.[124]—The stomach is exposed through Fenger's incision, a cut is made into it, and a tube introduced and fixed by a single catgut stitch. Two parallel folds of the stomach are then raised up, one on each side of the tube, and their summits are sutured by two or three Lembert sutures above and the same number below the tube. The sutures are cut short. Two similar parallel folds are again raised up and again stitched, and, if necessary, a third tier is added. A most

efficient valve is thus formed. The stomach is fixed by one or two sutures to the anterior abdominal wall.

FIG. 494.—GASTROSTOMY. KADER'S METHOD.

Depage's Method.—Depage[125] has devised another method of performing gastrostomy which is rather complicated and more difficult of

FIG. 495.—GASTROSTOMY. KADER'S METHOD.

performance, but apparently no more efficient than the operations just described.

In all these methods a soft-rubber catheter, closed by a clip, should always be kept in the stomach, as the opening so readily contracts.

In a recent case I have efficiently kept the opening patent by a short solid India-rubber plug similar to the form employed for keeping open a sinus in the antrum.

In advocating the earlier and more frequent performance of the operation of gastrostomy in cases of dysphagia incapable of relief by ordinary means, I feel that I can do so as the result of ample experience of its beneficial results.

Jejunostomy.—Jejunostomy is an operation occasionally called for as a means of giving relief and prolonging life in patients suffering from advanced disease of the stomach, where on exploration it is discovered to be impracticable to perform gastrectomy, gastrostomy, or gastro-enterostomy. The indications for the operation are: 1. Extensive cancer of the stomach too advanced for gastrectomy, and in which

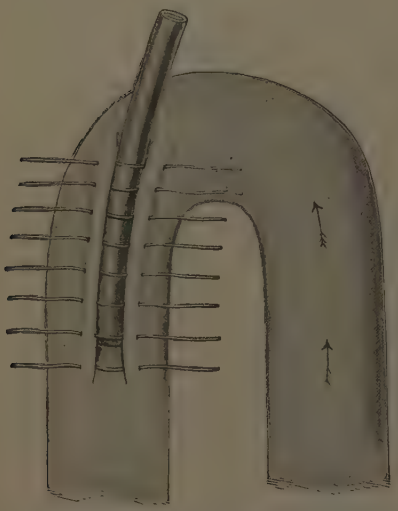

FIG. 496.—JEJUNOSTOMY BY A MODIFICATION OF WITZEL'S OPERATION FOR GASTROSTOMY (FIRST STAGE).

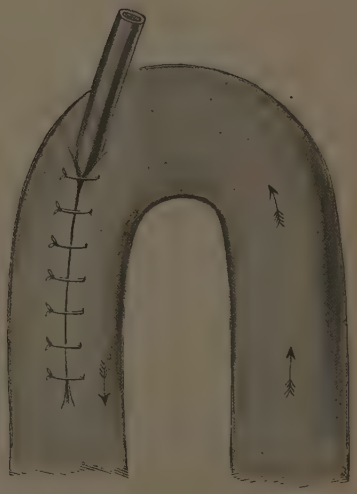

FIG. 497.—SECOND STAGE OF THE OPERATION SHOWN IN FIG. 496.

no healthy spot of sufficient size on the stomach wall can be found for the purpose of gastrostomy or gastro-enterostomy. 2. General cicatricial contraction of the stomach, simple in character and due to the swallowing of caustic fluid, in which the stomach has been so far damaged that it no longer performs its functions or even allows the proper passage onward of food. 3. In very extensive gastric ulceration with deformity of the stomach, as in hour-glass contraction, where it is impracticable to perform any of the ordinary operations with probability of success.

It has also been suggested in pronounced hyperchlorhydria in preference to gastro-enterostomy in order to avoid peptic ulcer of the jejunum; but as the latter is extremely rare and practically only associated with anterior gastro-enterostomy, a method that is being replaced

by the posterior operation, I do not think surgeons generally will be likely to endorse Neumann's suggestion.

Modes of Operation.—For any operation to be a success the bowel must be so placed that it will serve the two purposes:

(1) To permit the passage onward of the bile and pancreatic fluid poured into the intestine above the artificial fistula. (2) To allow of food being introduced through the fistula without fear of regurgitation, either of the food or of the intestinal contents.

The operations now used are: (1) A *modification of Witzel's method* of gastrostomy, in which a No. 12 rubber catheter is stitched into an opening in the jejunum and afterward the catheter is buried in a groove in the bowel for a distance of about 2 inches, the line of suture being fixed to the abdominal wall (see Figs. 496 and 497).

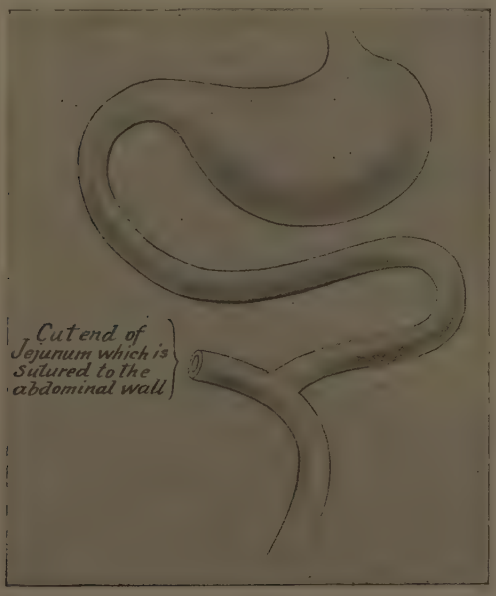

FIG. 498.—JEJUNOSTOMY BY MAYDL'S METHOD.

(2) *Maydl's method* of dividing the jejunum, implanting the proximal cut end into the distal portion a few inches from the original line of section, the open end of this section being fixed to the skin (Fig. 498).

(3) *Mayo Robson's Method.*—It consists in taking a loop of the beginning of the jejunum just sufficiently long to reach the surface without tension; the two arms of the loop are short-circuited about 3 or 4 inches from the surface, the short-circuiting being done either by means of sutures around a decalcified bone-bobbin or by sutures alone; personally I prefer the former. A small incision is then made into the top of the loop just large enough to admit a No. 12 soft-rubber catheter, which is inserted and passed for 3 inches down the distal arm of the loop; this is fixed to the margin of the incision in the gut by a silk or Pagen-

stecher's suture, and the entrance of the tube into the bowel is further guarded by two purse-string sutures, one over the other. The top of the loop is fixed to the skin by one or two stitches and the wound closed. The patient can then be fed at once with some peptonized milk and brandy. The whole operation can be done in from fifteen to twenty minutes and with very little visceral exposure.

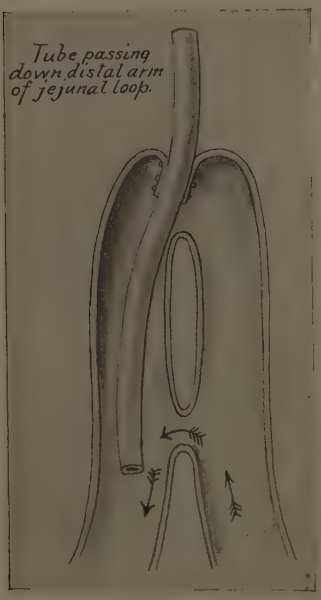

FIG. 499.—JEJUNOSTOMY BY MAYO ROBSON'S METHOD.

Should the patient be too ill to bear the little extra time occupied by the short-circuiting, the tube may be inserted as directed and surrounded by two or three purse-string sutures, a proceeding which can be accomplished in a few minutes. In this case the loop of bowel must not be brought to the skin, but had better be fixed by sutures to the peritoneal margin and the aponeurosis, in order to leave part of the lumen of the attached loop within the abdomen for the direct passage onward of the intestinal fluid with the bile and pancreatic secretion.

GASTRO-ESOPHAGOSTOMY.

In certain cases of impermeable cicatricial stenosis of the lower end of the esophagus and in case of cancerous stenosis, whether involving the esophagus alone or the cardiac end of the stomach along with it, surgery has hitherto been impotent, so far as a radical operation is concerned, and such cases have been treated in the past by gastrostomy. Now that the pneumatic chamber has become a more practicable help to the surgeon, I think we may look forward to accomplishing in man what has been proved possible in the lower animals.

Sauerbruch[127] has published the results of some of these experiments on dogs, which have been carried out with complete success, although the first attempts made by Mikulicz led to skepticism as to the possibility of such operations.

The conditions necessary to success appear to be perfect asepsis and accurate anastomosis, in which the Murphy button has played a part, but which might doubtless be accomplished by simple suture or by the use of continuous sutures over a decalcified bone-bobbin. Sauerbruch made a free application of Lugol's solution to the surface to be anastomosed, in order to secure rapid adhesion.

Of 13 dogs on which the operation of gastro-esophagostomy was done, 10 recovered, while the remaining 3 died in consequence of complete hernia of the stomach into the thoracic cavity, due to faulty

suturing of the small conic prolapse to the esophageal opening in the diaphragm. Sauerbruch found in these experiments that the stomach could be readily applied to the upper third of the esophagus and that the lower half of this canal could be excluded by anastomosis.

Partial resection of the esophagus was found to be a very difficult and unsatisfactory operation, on account of the inelasticity of the canal and its close attachment to surrounding structures, and of the consequent impossibility of bringing the divided ends together and of maintaining them in contact by sutures. It is not difficult, however, after the stomach has been fixed to the upper part of the thoracic esophagus to resect the canal below the seat of anastomosis and, finally, to invert the lower end into the cavity of the stomach and to cover it with a row of peritoneal sutures. The upper end of the divided esophagus is secured by a ligature. This operation was performed on 11 dogs without a single fatal result.

That such operations as are here described are practicable on man, Sauerbruch has convinced himself by experiments on the human cadaver. The stomach, he states, is sufficiently mobile, the esophagus can be readily separated from surrounding nerves and vessels, and sufficient exposure can be attained by a single incision in the fourth or fifth intercostal space.

DILATATION OF THE STOMACH.

Dilatation of the stomach may be acute or chronic. The acute condition constitutes a distinct disease and is treated in a separate chapter.

Chronic dilatation may be obstructive or atonic. The obstructive form has already been referred to in the sections on Ulcer and Cancer.

Atonic Dilatation of the Stomach.—The capacity of the stomach cannot be taken as a guide in estimating its dilatation. A moderate degree of dilatation is common among a certain class, such as the mill operatives of Yorkshire and Lancashire, who live so much on tea and farinaceous foods, or in those living on bulky farinaceous food, such as potatoes. Moderate dilatation is also commonly associated with chronic catarrh.

It is, however, only in extreme atonic dilatation of the stomach that a surgical opinion is usually sought, and in such cases there is not infrequently some mechanical cause to account for the dilatation. The condition is due to a weakened state of the muscular coat of the stomach, so that there is deficient peristalsis and the contents are not pressed toward the pyloric canal sufficiently rapidly for the stomach to empty itself in normal time. In well-marked cases a succussion splash may be found in the morning before breakfast, and if the gastric contents be syphoned off, the remnants of food taken in the meal of the previous evening will be found, which, although digested, are retained simply from want of expulsive force.

The disease is characterized by flatulency and a sense of oppression, with fulness at the epigastrium. Constipation is a marked symptom.

Owing to pressure upward on the heart, palpitation is often complained of. Thirst is increased and, as a rule, the appetite is poor. In advanced cases vomiting may be present, in which case there will be emaciation that may become extreme.

The myasthenic variety of dilatation may be dependent on—(*a*) degeneration of the muscular fibers, fatty or colloid; (*b*) want of nerve tone or paresis of the gastric nerves; (*c*) actual organic disease of muscle, due to fibrosis.

In some cases the chief symptoms of atonic dilatation may be dependent on the size of the stomach. For instance, Bamberger[129] mentions an extreme case in which the stomach held 70 pints of fluid.

Treatment.—Atonic dilatation not dependent on any mechanical obstruction at the outlet is, as a rule, first a subject for general and

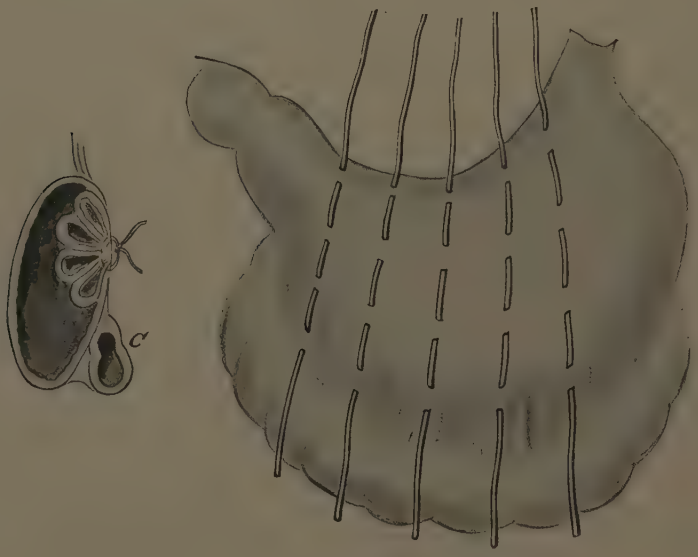

FIG. 500.—GASTROPLICATION. (Moynihan.)

medical treatment, and it is only in very exceptional cases where, after failure of careful dieting combined with electrical treatment and lavage, when the nutrition of the patient and the general health are impaired, that surgical treatment is either desirable or advantageous.

In such cases, however, where medical treatment has failed, surgical treatment must be considered and, as a rule, gastro-enterostomy will be the operation of choice, for by securing thorough evacuation of the stomach at regular intervals and preventing gastric stasis the functions of the stomach may be completely restored by a further perseverance with medical and general treatment.

Gastroplication.—In some cases gastroplication may be worth considering, as it is neither difficult nor attended with serious risk. Bircher reported 3 cases in 1890, and Weir, of New York, published

a paper on the subject in 1892. In 1900 I was able to collect from all sources 28 cases.[128]

Personally, I have only performed the operation on two occasions and I do not think that I shall be likely to repeat it, as although in one of my patients, a man of thirty-five, in which it was used to supplement a Hahn's operation, it was followed by complete recovery and the patient was well when heard of two years later; yet in another patient, a woman of fifty-six, on whom I performed the operation, I had subsequently to do a posterior gastro-enterostomy, which was followed by complete restoration to health.

Moynihan published the description of an operation for gastroplication in the *Lancet* for 1898, which the appended figures (Fig. 500) serve to illustrate, and should the operation have to be done this method seems superior to any other that has been described.

Acute Dilatation of the Stomach.—Although acute dilatation of the stomach is said to be a rare condition, the fact that so many cases have been reported since Hilton Fagge[130] first drew attention to it, shows that it is far from uncommon; and seeing that it is frequently speedily fatal from symptoms of heart failure with almost complete suppression of urine, there have been doubtless very many deaths from this disease which have been wrongly attributed to other causes.

My reason for making this statement is because a number of the reported cases have only been recognized as acute dilatation when it was too late to remedy the condition, but also from the fact that in several cases that have come under my own notice no diagnosis had been arrived at before I suggested the passage of a stomach-tube, and that in 4 cases seen sufficiently early gastric lavage was the means of saving life.

When I was on the acting staff of the Leeds Infirmary 7 cases came under notice within a comparatively short time: 1 case, a man of fifty-five, was admitted under the care of a colleague as acute intestinal obstruction, and the stomach was opened and drained without affording relief. At autopsy nothing was found to account for the dilatation. One occurred in a woman of twenty-six, a month after excision of the hip, and death occurred on the fourth day. The only apparent cause was the eating of an apple, which was followed by uncontrollable vomiting, and at the post-mortem examination, beyond dilatation of the stomach and duodenum, nothing was found to account for the condition. One occurred in a patient suffering from ulcerative endocarditis, and at the post-mortem examination nothing was found in the gastro-intestinal tract to account for the dilatation. One case had had a choledochotomy performed ten days before and the wound had healed by first intention, when suddenly, without apparent cause, she began to vomit, the abdomen rapidly distended, the urine was suppressed, and death from collapse occurred within two days. Unfortunately I was away at the time, so that I had not the opportunity of putting into practice what brought about recovery in other cases. A woman of thirty-five, on whom I had performed cholecystotomy a week previously and who had

progressed most satisfactorily, was suddenly seized on the eighth day with epigastric pain followed by vomiting, which soon failed to empty the stomach, so that the stomach not only filled the upper abdomen, but extended well below the umbilicus, and by pressure on the heart and lungs led to great shock, rapid breathing, and a quick pulse. The face was livid and pinched, the temperature subnormal, and the urine almost suppressed. The passage of a stomach-tube gave exit to a quantity of gas and several pints of brownish fluid. Under repeated gastric lavage for two days and rectal feeding recovery was rapid and complete. Another case, a woman of twenty-nine, on whom I had performed hysterectomy for myoma, progressed satisfactorily without a single drawback for a fortnight, when she ate a raw apple and was suddenly seized with vomiting and almost total suppression of urine. Within thirty-six hours the stomach was down to the pubes and death appeared to be impending from collapse. Gastric lavage with rectal feeding and the administration of strychnin subcutaneously was followed by complete recovery within a week.

Thomson[131] collected 44 cases, including 5 in which he had performed the autopsy. In 12 of the cases acute dilatation followed on surgical operations, but in all these cases the operation had progressed favorably until the gastric complication supervened. Riedel has reported 2 cases of acute dilatation following operations on the gall-bladder which recovered, and Müller 5 cases, of which 2 recovered.

Neck[132] has collected 64 cases, of which 44 came to autopsy, 47 died from a few hours to thirteen days after the beginning of acute symptoms, 17 recovered; none of these were submitted to secondary operations.

Etiology.—In the great majority of cases no apparent cause has been found at autopsy to account for the condition, even when the dilatation followed on operation, as in nearly all the reported cases the surgical course had been favorable before the gastric complication supervened, and in many cases no injury, either operative or accidental, preceded the attack. In 2 cases within my experience the eating of a raw apple was the apparent cause, and in 5 of Thomson's cases indiscretion in diet appeared to be the exciting cause.

Torsion of the stomach given as an explanation of a case by Wiesinger[133] comes under another category (see Gastric Volvulus), but that mechanical difficulties may sometimes be the exciting cause a case of my own would seem to prove, there being found at autopsy a well-marked band of adhesions stretching between the pylorus and gall-bladder. The occurrence of several cases after an abdominal injury has given rise to the suspicion that an injury to the solar plexus might be the cause, but on post-mortem examination the great ganglia appeared to be normal.[134]

Other mechanical explanations have been given—pressure of the distended stomach on the third part of the duodenum (Box and Wallace); pressure of the superior mesenteric vessels on the duodenum which they cross transversely (Albrecht); spasm of the pylorus (Pepper and Stengel). Fagge considered the cause to be excessive secretion in the stomach, and

this was supported by Henry Morris, who termed the condition gastro-succorrhea.

The true explanation seems to be, first, a paralysis of the stomach which leads to overdistention with gas and excessive secretion, that in its turn leads to kinking at the pylorus or at the duodenojejunal flexure. The appearance post-mortem is shown in Fig. 501.

The stomach is enormously distended and sharply bent on itself in the shape of a large U, which occupies the greater part of the abdominal cavity. The walls of the stomach are usually thin and the mucous membrane shows various stages of congestion with areas of hemorrhage and superficial necrosis with hemorrhagic infarcts. In nearly all cases

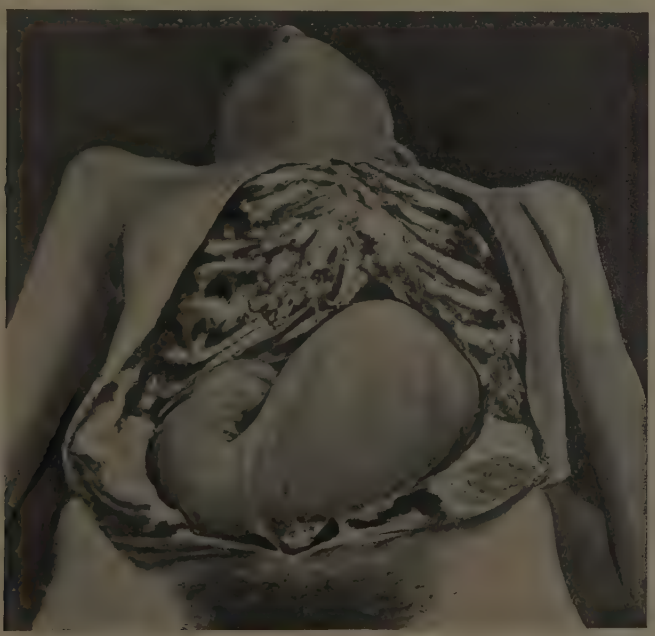

FIG. 501.—ACUTE DILATATION OF THE STOMACH COMPLICATING PNEUMONIA AND PLEURISY. (Campbell Thomson.)

the duodenum up to the mesentery participates in the dilatation, and in 1 case at least the upper part of the jejunum was also distended. The small intestines are usually empty and pushed down into the pelvis. The pylorus is usually dilated and there are no signs of peritonitis.

Symptoms.—A sudden onset with speedy development of acute symptoms characterizes the disease and only occasionally have discomfort after food or pain preceded the acute stage.

Acute pain, followed by vomiting which gives no relief, characterizes the disease from beginning to end, but as soon as the distention becomes marked the upward pressure leads to respiratory and circulatory disturbances, quick breathing, lividity, rapid, feeble pulse, agonized expression of countenance, and great restlessness. The pulse and tem-

perature become paradoxic, the latter falling and the former rising. On examining the abdomen it is seen to be enormously dilated, especially in the upper part, and the breathing is altogether costal. Extensive resonance is found on percussion and a succussion splash can usually be obtained. Visible peristalsis has been absent in all the cases I have seen and has seldom been observed. Thirst is unquenchable and drinking increases the distress. The urine, at first scanty, in the later stages is suppressed. In 1 case related by Broadbent tetany was present. On emptying the stomach it rapidly refills, so that the process may have to be repeated over and over again; in 1 case of Broadbent's 8 pints were removed, but the stomach speedily attained its former volume.

Acute Postoperative Dilatation of the Stomach.—It seems not improbable that some of the cases of ileus after abdominal operations may be caused by acute dilatation of the stomach, which, when once initiated, tends to persist and get worse, owing to the distended stomach dragging on and kinking the duodenum, thus leading to shock by pressure on the heart, without there being any signs of sepsis. Hence, in all cases of ileus after operation the use of the stomach-tube should not be neglected.

Attention has been specially drawn by Müller[135] to dilatation of the stomach following upon abdominal operations. In some of these cases the gastric distention is only a part of a general involvement of the intestinal canal due to peritonitis. The septic condition induces a paresis of the bowel walls and distention of the gut rapidly follows. In other cases, and it is these to which Müller draws particular attention, the dilatation of the stomach is due to pressure upon the duodenum by the superior mesenteric artery. When a large ovarian cyst or fibroid tumor of the uterus is removed the intestines, compressed for many months or years to the upper part of the abdomen, sink down into the pelvis, and so drag upon the superior mesenteric artery as to compress the duodenum in the manner already described.

In all abdominal cases where vomiting is severe or long continued, washing out of the stomach should be adopted. A single washing almost always suffices to relieve the patient and to check the vomiting, but in some few cases a daily (or oftener) lavage for two, three, or four days may be desirable. In all abdominal cases in which vomiting is a symptom threatening to persist, an examination of the abdomen, with the object of discovering any dilatation of the stomach, is desirable.

Treatment.—Although in the great majority of reported cases the issue has been fatal, I feel confident that if the cases were seen in time and heroically treated recovery would be probable in nearly all. The cases I have treated personally seem to me to demonstrate this.

Lavage of the stomach repeated as often as necessary should be carried out as soon as the condition is recognized, and if the hypersecretion tends to continue I should have no hesitation in advising gastrojejunostomy, a method I first suggested in 1900. The administration of strychnin subcutaneously assists the heart and seems to me

to be of benefit. All food should be withheld and rectal alimentation adopted. Opening and draining the stomach externally has always been attended with fatal results and should only be adopted as a last resort. The knee-elbow position recommended by Zade has in some cases given relief and is always worth trying. In 1 case rolling a patient over on to the face brought about relief.

SIMPLE TUMORS OF THE STOMACH.

Benign tumors of the stomach are rare, and unless they invade the orifices may produce no symptoms, though when ulcerating they may simulate malignant disease.

Adenoma.—Simple glandular tumors of the stomach may be single or multiple, and they are specially liable to form polypi. They may be found in any part of the stomach, but are not infrequently found to occur at the pyloric end, where they may give rise to pyloric obstruction and dilatation of the stomach.

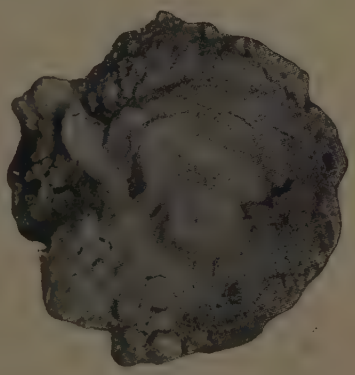

FIG. 502.—ADENOMA REMOVED FROM STOMACH. (Hinds' case.)

In a case of my own a sessile adenoma gave rise to pyloric obstruction with gastric dilatation, which was cured by removal of the growth, the longitudinal incision being afterward stitched up transversely, as in the ordinary operation of pyloroplasty. In another case under the care of a colleague a pedunculated adenoma the size of a cherry, acting like a ball-valve, produced similar symptoms, which were cured by its removal. When the tumor is large it may form a freely movable epigastric tumor, as in a case reported by Sutton and in another reported by Hinds.

The symptoms may resemble those of cancer by inducing coffee-ground vomiting and wasting.

Adenoma may pass on into carcinoma or be associated with it, as in a specimen now in the Leeds Museum.

Ebstein[137] collected 24 cases of mucous polypi, 15 in men and 8 in women, in 1 the sex not being mentioned. He states that the frequency of these tumors increases after forty years of age; in one-half the tumors were solitary, in the rest multiple, even up to 200 in number. The mucous membrane over them may be smooth or villous.

Treatment.—When adenoma is polypoid, it should be removed and the pedicle ligatured. If it forms a sessile tumor it should be freely excised and the healthy edges of mucous membrane brought together by suture.

If the pylorus be invaded by a sessile adenoma the growth should be freely excised and a gastro-enterostomy performed, but if the deeper

layers of the stomach wall are invaded, pylorectomy or partial gastrectomy should be performed.

Lymphadenoma.—This is a rare form of tumor characterized by the appearance of multiple polypoid projections into the cavity of the stomach, as shown in Fig. 503.

Pitt[138] stated that he had only been able to find 17 cases recorded in literature.

The neoplasm usually arises in the mucous membrane or in the submucosa, but it may arise in the serous coat of the stomach. In the special case reported by Pitt the disease was evidently malignant and had invaded other viscera. In a case reported by Normans[139] symptoms were absent, although the mucous membrane of the stomach was everywhere covered by dendriform projections and wart-like growths. The projections may ulcerate and give rise to severe hematemesis. In the cases recorded by Cornil and Ranvier[147] the tumor formed in the deep mucosa or in the submucosa and sent prolongations into the outer coats of the stomach. The condition is practically only of pathologic interest.

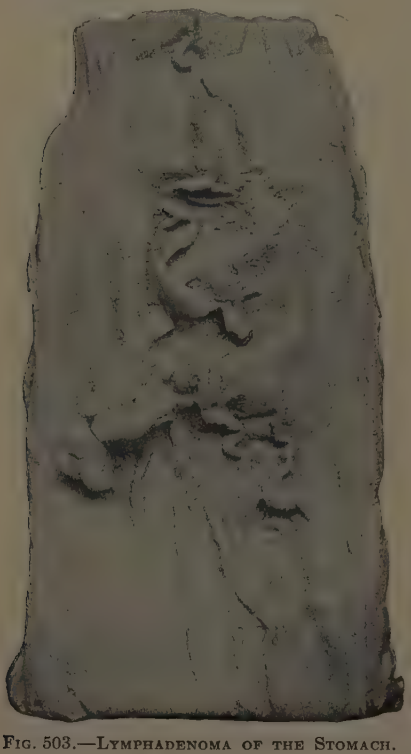

FIG. 503.—LYMPHADENOMA OF THE STOMACH. (From *Diseases of the Stomach*, Mayo Robson and Moynihan.)

Myoma.—Tumors resembling uterine myomata histologically may spring from the muscular coat of the stomach and push the mucous membrane before them, projecting into the stomach as sessile or polypoid tumors or, pressing toward the serous surface, they may project into the abdomen and form immense tumors, as in Von Erlach's case, in which a tumor weighing 5½ kilograms was removed successfully from the anterior wall of the stomach,[140] and in Von Eiselsberg's case, in which a fibromyoma the size of a man's head was successfully removed from the greater curvature of the stomach.

Of 19 cases reported, 11 were external, 6 internal, and in 2 details are not given. If occurring near the pylorus, obstruction may be produced, as in Herhold's[141] case, or they may ulcerate and give rise to hematemesis.

The treatment of these tumors is removal, and as they are benign it is unnecessary to take away more of the wall of the stomach than necessary for removal of the tumor.

Lipoma.—Lipomata in the stomach wall are extremely rare. They may arise from the submucous tissue and project into the cavity of the stomach, or from the subserous coat and project into the peritoneal cavity. In Virchow's work (*Die Krankhaft. Geschwülste*) is figured a lipoma arising in the submucous tissues near the pylorus. If diagnosed, these tumors can be readily removed by enucleation,

A case of lipomyoma has been reported by Kunze,[142] who removed it. A diagnosis of a mesenteric tumor had been made.

Cysts.—Small cysts from obstruction of gland ducts are not uncommon. Ruysch[143] described a gastric dermoid cyst containing hair. Engel Reimers described a multilocular lymphangioma of the stomach wall occurring beneath a chronic gastric ulcer of the lesser curvature (*ibid*). Albers mentions a cyst 2½ inches long on the lesser curvature of the stomach in a child. Ziegler performed laparotomy for a cyst of the stomach following injury; it formed a tumor, for which the operation was undertaken, and after emptying the cyst it did not refill. Jonathan Hutchinson[144] described a cystic tumor, the size and shape of a walnut, situated near the pylorus between the muscular and mucous coats. Anderson[145] described multiple cysts of the stomach and intestines which he believed originated from inclusion or embryonal rests after the manner of dermoids. Read[146] described a case of a man of sixty-two, who died after an illness of five weeks, and at autopsy a cyst was found completely encircling the stomach. It contained clear fluid and a fatty substance with black streaks of extravasated blood.

PHLEGMONOUS GASTRITIS.

Synonyms.—Submucous gastritis; Suppurative gastritis; Phlegmon ventriculi; Gastritis phlegmonosa; Linitis plastici et suppurativa; Gastrité interstitielle suppurative.

Definition.—An acute infective inflammation of the stomach wall with suppuration starting in the submucous and at times passing into the muscular, mucous, and serous coats. It may be circumscribed or diffuse. In the former there may be a single abscess of the stomach wall; in the latter are numerous foci of suppuration. The first description of the condition was given by P. Bevel in 1656. Of 50 cases tabulated by Jacoby, 30 were of the diffuse and 19 of the circumscribed varieties.

It may occur at any age, the youngest recorded case was aged eleven, the oldest seventy-six. Glax's[148] table shows that age has no influence, for of 34 cases, 9 occurred between twenty and thirty years of age and 7 between seventy and seventy-six.

Though ulcer is more frequent in women, phlegmonous gastritis is more frequent in men, in the proportion of 4 to 1.

Etiology.—In the primary form the direct cause is bacterial invasion by pyogenic organisms that find entry through lesions in the superficial epithelium; thus, ulcer, cancer, and traumatism may be predisposing causes. Ziegler[149] found streptococci partly free in the

tissues and partly in the protoplasms of the cells. In other cases streptococci have also been found in the exudate. In the secondary form are found metastatic deposits of the organisms causing the fundamental disease, for instance, in puerperal fever, typhoid, pyemia, or smallpox.

Symptoms.—The symptoms are those of an intensely acute gastritis with profound general disturbance and a rapidly fatal termination. Sudden onset, severe epigastric pain, marked epigastric tenderness, incessant vomiting, faintness, and collapse being the prominent symptoms.

The temperature is variable, though usually high, and the pulse is rapid and of poor quality. Peritonitis though often present may be absent or may not occur until late, as in some cases the serous coat escapes. In some cases the end occurs in coma, in others the faculties are clear until death.

In the circumscribed form the disease, though usually starting acutely, may pursue a more prolonged course and a palpable swelling may form. The abscess may also burst into the stomach and be vomited, or into the peritoneum and cause violent general peritonitis. If it burst into the stomach recovery is possible, and there are in the museum at Erlangen two specimens suggestive of this.

The clinical course may be prolonged for many weeks, the patient being in constant pain, with vomiting and inability to take food, death ultimately taking place from exhaustion. (See "The Surgery of the Stomach," by Mayo Robson and Moynihan,[151] for a résumé of all the cases of phlegmonous gastritis that had been recorded up to the date of publication, 85 in number.)

Pathology.—In the diffuse form the whole stomach or only a limited portion may be affected, the pyloric end being the most common site.

Ulcer, cancer, or ulcus carcinomatosum may be present, but whatever be the predisposing cause, the affected area is acutely inflamed and infiltrated with pus, which may have collected here and there into small abscesses in the submucous coat. In the later stages the submucous coat may have disappeared and been replaced by semiliquid pus with areas of necrotic mucous membrane over it. The serous coat frequently escapes, though in some cases there is well-marked visceral peritonitis over the affected area. Abscesses or areas of infiltration may also be found in the muscular coats.

In the circumscribed form an abscess from the size of a walnut up to that of a large orange may be found in the submucosa. It may be bulging internally and externally and involving the serous or mucous coats.

Treatment.—Under the existing difficulties of diagnosis, the treatment both of the diffuse and circumscribed forms can be only symptomatic.

If phlegmonous gastritis can be diagnosed, surgical treatment is advisable, especially in the circumscribed form, in which the indications

are quite clear; viz. to open the abdomen, search for, and open and drain the abscess.

I have operated on a case in which an abscess had burst into the stomach and where complete recovery resulted after posterior gastro-enterostomy. Several similar cases have been reported.[150]

Though it is impossible positively to state that the reported cases were really primary gastric abscesses, it is probable that some of them were such, as Dittrich has found cicatrices in the submucosa pointing to the possibility of healing after the spontaneous evacuation of circumscribed gastric suppurations.

PRIMARY GASTRIC ANTHRAX.

Though infection of the stomach by anthrax might reasonably be expected to occur occasionally, so far as I can discover the condition is an extremely rare one, a case reported in the *Medical Press*, 1904, p. 199, being the only one I can find recorded. (See Vol. I., p. 503.)

INFECTIVE GRANULOMATA AFFECTING THE STOMACH.

Among the infective diseases must be considered tuberculosis, syphilis, typhoid, and glanders.

Tuberculosis.—The normal stomach is not a favorable nidus for the development of tubercle, though the occasional occurrence of large and small tuberculous foci in the stomachs of both children and adults shows that the gastric walls may be successfully attacked by the bacilli in some exceptional cases. Orth fed rabbits with tubercle bacilli, but although he obtained intestinal tuberculosis seven times, on only one occasion did he succeed in infecting the stomach.

It may occur in two forms: (1) miliary tuberculosis, affecting the serous coats, a common condition in tuberculous peritonitis; (2) tuberculous ulceration of the mucous membrane, an extremely rare disease.

Letulle in 108 autopsies of phthisical patients found tuberculosis of the stomach only once, and in that case there were ten submucous nodules the size of peas, containing giant-cells and tubercle bacilli.

Petruschky claims to have proved by the effect of tuberculin that chronic gastric ulcers are generally tuberculous, but clinical experience does not support the view.

The symptoms are variable, at times being absent, at others associated with pain after food, vomiting, and hematemesis.

In 1 case that came under my care a tuberculous ulcer of the pylorus and another of the duodenum produced strictures followed by dilatation of the stomach. The disease of the stomach was associated with enlargement of the lymph-glands and with general tuberculosis of the peritoneum.

Gastric tuberculosis is generally rather of pathologic than clinical interest, and is usually only discovered after death from other tuberculous affections.

Primary tuberculosis of the stomach may simulate cancer, as is well illustrated in a case reported by Ruge.[154] The author is of opinion that the stomach lesion was the primary one in this case, and he establishes his proposition by a process of exclusion.

Syphilis of the Stomach.—Syphilis of the stomach may occur in the form of gumma or ulcer, the former when exaggerated may cause a tumor resembling cancer, and the latter when extending may lead to hematemesis or perforation, and when healing may cause stricture or other deformity.

From a surgical point of view the subject is of considerable importance, as surgical treatment, either gastrectomy or gastro-enterostomy, might be undertaken for a syphilitic tumor under the idea that cancer was being dealt with, whereas if a correct diagnosis had been made the disease would have yielded to medical treatment alone. On the other hand, it is important to bear in mind that medical treatment may be carried so far in a doubtful case as to render radical surgical treatment impossible, should the disease prove to be cancer.

The lesson to be learned is that a careful history should always be obtained in every case of tumor or chronic ulcer of the stomach, and if a history of syphilis is obtained, a fair trial of specific treatment should be given, but not continued too long if good results are not soon obtained.

Flexner[155] could only find 14 reliable cases of syphilis of the stomach, but many other single cases have been recorded.

Dieulafoy says that it is not so common as generally supposed, and that as the symptoms differ in no way from those of simple ulcer, a careful history should be sought in every case. In 1898 he[161] published a case of ulcer of the stomach yielding to biniodid of mercury after all other treatment had failed.

Keser,[156] Dubec,[157] Einhorn,[158] have each reported one or more cases presenting symptoms of ulcer and cured by specific treatment.

Fenwick[159] remarks that 10 per cent. of a series of chronic ulcers of the stomach gave a history of syphilis, but he thinks that in only 5 per cent. was there a causal relationship. Chiari examined the stomach in 243 autopsies of undoubted syphilis, 145 hereditary and 98 acquired. In only 3 cases could he find direct evidence of gastric syphilis, which goes to prove that syphilis of the stomach is a rare disease.

Lymphadenoma.—Very few cases of lymphadenoma of the stomach have been recorded. In those reported by Cornil and Ranvier the tumors formed in the deep mucosa or submucosa and sent prolongations into the outer coats.

Glanders.—Only 1 case is on record as having occurred in the human stomach. The tendency seems to be toward ulceration by invasion of the mucous surface from below.

Typhoid.—Typhoid ulceration of the stomach appears to be a rare disease, though it may occasionally occur, giving rise to pain after food and sometimes leading to hematemesis. It has been observed several times in the esophagus, giving rise to dysphagia and to subsequent contraction, leading to stricture.

PLASTIC LINITIS (CIRRHOSIS OF STOMACH).

The term plastic linitis has been used somewhat indefinitely to indicate a chronic induration and thickening of the walls of the stomach with a marked diminution of the gastric cavity. It is an extremely rare condition that would be seldom described if all cases of diffuse sarcoma or carcinoma of the stomach walls could be excluded.

In true plastic linitis there is no evidence of new growth, the thickening being due to hypertrophy of the muscular coat and infiltration of the wall of the stomach with inflammatory exudation, which in places has been converted into fibrous tissue. Almost similar appearance may be produced by cancer, as in the so-called "leather-bottle stomach," of which a photograph from the Royal College of Surgeons' Museum furnishes a good example. (See chapter on Cancer.) Einhorn,[164] Osler,[165] Hemmeter,[167] Leith,[166] Clifford Allbutt, and others recognize the condition and report cases. John G. Sheldon reports fully[168] a characteristic case treated successfully by gastro-enterostomy and furnished abstracts of 10 cases.

"I am of the opinion, however, that a benign diffuse cirrhosis of the stomach, though a rare condition, does occur. Of course it is possible that a carcinomatous process may develop in a stomach already the seat of chronic cirrhotic changes; but it is improbable that such a case has been recorded" (Sheldon).

The **symptoms** are those of chronic gastric irritation associated with epigastric pain, tenderness, and vomiting. Emaciation occurs as the result of inability to take or retain food. A hard tumor in the epigastrium extending under the left costal margin is suggestive of carcinoma, though the tenderness of the epigastrium and the rigidity of the recti point to inflammation rather than growth.

Even in the absence of new growth, free HCl may not be found, as in Roux's case. Owing to the presence of perigastritis, numerous adhesions may be found.

Treatment.—Medical treatment in the shape of careful dieting, rest, and sedatives will have usually been tried before the surgeon sees the case. In plastic linitis surgical treatment is called for.

If there is reason to believe that cancer or sarcoma are not causing the trouble, a well-planned gastro-enterostomy, as in Roux's case, offers a good chance of relief or cure.

If, however, there is a suspicion of the disease being malignant, complete gastrectomy is advisable, especially if the organ is found to be free from complex adhesions, and the lower end of the esophagus can be dragged down sufficiently to render approximation of the duodenum or jejunum possible.

If the patient's condition or the condition of the parts renders either gastro-enterostomy or gastrectomy impracticable, the operation of jejunostomy as described on p. 942 will enable the patient to be fed artificially, and by giving rest to the stomach may so far alleviate the symptoms of irritation as to enable food to be again taken by the mouth after a little time.

GASTRIC TETANY.

Although the term tetany was first employed by Corvisart in 1852, the subject was first prominently brought before the profession by Kussmaul[169] in 1869.

Gastric tetany may vary in degree from mere cramp of the flexor muscles of the arms and of the calves to tonic spasms of the muscles of the arms and legs, of the abdomen, and of the face, neck, and maxillæ, and in severe cases the condition may assume the form of opisthotonos or emprosthotonos.

To make a distinction between the severe and fatal form of gastric tetany and the tetanoid spasms associated with gastric dilatation is purely arbitrary, and it seems more rational to include all cases of tetany and tetanoid spasms dependent on stomach diseases under the term gastric tetany.

Moreover, to conclude that gastric tetany is almost necessarily fatal is to my mind a great mistake, as an extensive experience of the disease, both of the mild and severe varieties, has convinced me that under efficient surgical treatment hardly any case is hopeless.

Numerous theories have been advanced to account for the disease—Kussmaul[169] thought the spasms due to desiccation of the tissues. Germain-Sée adopted the reflex theory, arguing that the spasms are aroused by stimulation of the sensory nerves of the stomach. Albu[170] advanced the theory of auto-intoxication. My own belief[171] is that a poison is formed in the stagnant contents of the stomach which, being absorbed, renders the nerve centers more responsive to reflex stimuli.

In almost all recorded cases of gastric tetany, dilatation of the stomach has been present, and with few exceptions the cause has been simple and not malignant.

Warbasse[172] has reported a case in which tetany was associated with foreign bodies in the stomach and was cured by their removal.

In all the cases I have seen, ulcer has been the primary cause of the pyloric stenosis and of the gastric dilatation; and hyperchlorhydria has been present; but I know of 1 case in which the dilatation was due to cancer.

Symptoms.—The symptoms vary greatly, according to the severity and duration of a seizure. In many cases the tingling or numbness, though frequently noticed, is nothing more than an unpleasant sensation whose significance is never appreciated. Cramps in the extremities, noticed from time to time soon after the patient gets to bed, are not attributed to their real cause until the surgeon makes a pointed inquiry as to their existence. When, however, there is a wide involvement of muscles, and especially when the attack is unduly prolonged, the physical suffering is intense and the most profound prostration may be witnessed. The pulse at the wrist may be quite imperceptible, though the tensely contracted vessel can be rolled beneath the finger. Consciousness may be lost for a time or the patient's mental balance gravely disturbed by the intensity of the suffering. Intermissions during an

attack are often observed. A seizure in which the wrists are flexed may slowly subside to be presently followed by one in which the wrists are extended. And so the posture of the limbs may vary from time to time. The muscles of the abdomen are affected in the severer cases, the abdominal wall feeling hard, tense, and absolutely unyielding. A severe and prolonged seizure of gastric tetany is thus almost as serious an ordeal as any patient may experience and live. It is these severe cases which furnish the large mortality recorded by v. Frankl-Hochwart, Müller, and others.

During the paroxysm the patient may mutter or shout unintelligibly, almost as if in delirium; words and phrases are run together unmeaningly. In all the well-marked attacks the signs of Trousseau, Chvostek, Erb, and Hoffmann are present. Trousseau's symptom is described as follows: "So long as the attack is not over, the paroxysm may be produced at will. This is effected by simply compressing the affected parts, either in the direction of their principal nerve-trunks or over their blood-vessels, so as to impede the venous or arterial circulation." Chvostek's symptom is shown by the very great increase in the mechanical excitability of the motor nerves of the part affected—a facial spasm, for example, being produced by tapping over the facial nerve near its exit from the stylomastoid foramen. Erb's symptom is shown by the great increase in the electric irritability of the nerves and muscles, especially to anodal stimulation. Hoffmann's symptom has reference to the heightened excitability of the sensory nerves, the slightest pressure on which may cause paresthesia in the region of distribution.

Treatment.—The medical treatment of gastric tetany consists in frequent and thorough lavage, rigid dieting, and the administration during the height of an attack of sedatives, bromids of potassium or ammonium, or, in the severer crises, of morphin hypodermically. It has been said and with some show of reason, that the washing out of the stomach excites the occurrence of tetany. The lavage is distinctly teasing and irritating, and if the cleansing of the stomach be inadequately done an ample quantity of putrid fluid may be left to provide a toxin for absorption—absorption which is rendered easier by the washing away of mucus from the lining of the stomach. But the lavage—and the point needs emphasis—should be very thoroughly done, and the surgeon must not desist until the fluid returns absolutely clean. If needful, chloroform may be given while the lavage is being carried out. Intravenous infusion of saline fluid may be adopted or copious hot-water enemata may be given.

The essential treatment of gastric tetany is surgical, as I had the privilege of first pointing out in a paper in the *Lancet*, November 26, 1898, when several cases were given as examples of successful surgical treatment. Since that time my experience has very largely increased, and out of a large number of cases on which I have operated I can state definitely that in no single case has drainage of the stomach by gastro-enterostomy failed to give relief. Moreover, at the same time that

relief from the tetany is secured, a cure of the disease producing it is accomplished.

From what has been said as to the pathology of the condition, it is clear that in almost all cases there is a grave mechanical obstacle to the onward passage of the food. It is this obstacle which causes dilatation and hypertrophy of the stomach. To relieve this obstruction and to do away with the stagnation of the stomach contents surgical measures are necessary. In simple cases pyloroplasty or gastro-enterostomy, the latter by preference, will be the methods of choice; in malignant cases a partial gastrectomy or gastro-enterostomy, as circumstances dictate. In hour-glass stomach gastrogastrostomy combined with gastro-enterostomy performed in the larger pouch, will, as a rule, be the suitable operation.

FUNCTIONAL DISEASES OF THE STOMACH.

Synonyms.—Hyperchlorhydria; Spasm of pylorus; Atony.

Dyspepsia.—Although the term dyspepsia is universally acknowledged to be unsatisfactory, the word is generally applied to cases in which during digestion pain or discomfort is experienced. When these symptoms are associated with organic disease, such as cancer, ulcer, stenosis of the pylorus, and dilatation of the stomach, the term dyspepsia is wrongly applied. It should be reserved for functional cases only in which the secretory or the motor functions of the stomach are interfered with, cases which, as a rule, are nervous in origin and should be treated medically.

It might be thought that functional dyspepsia ought to yield readily to dietetic and general treatment, but as a matter of general experience it is found that some of these cases are so ill defined and capricious and so influenced by the personal factor that the most elaborate diet schemes frequently fail to relieve, and the patient, losing faith in medical treatment, naturally wants to know if surgical treatment can do anything to relieve his trouble. In purely functional cases surgical treatment is unable to effect more than can be accomplished by general means, but in functional cases that have gone on to dilatation, with spasmodic stenosis of the pylorus, operative treatment will often afford complete and permanent relief, not only to the gastric symptoms, but also to the constipation and to the associated neurasthenia. It cannot, however, be too strongly insisted on that surgical means are only justifiable after very thorough and, if necessary, prolonged trial of medical treatment.

The functional disorders of the stomach may be divided conveniently into—(1) those in which there is an excessive acidity of the gastric juice, which leads to excessive secretion, to which the term acid dyspepsia or hyperchlorhydria is applied; and (2) those in which, at the same time that the gastric juice is diminished, there is impairment of the motor activity of the stomach, which cases are known as atonic dyspepsia.

Hyperchlorhydria.—Hyperchlorhydria is frequently associated with other gastro-intestinal diseases, especially ulcer of the stomach and duodenum, so that it is often difficult to say whether it is primary or

secondary. At first acid dyspepsia is simply an intermittent overproduction of HCl, which leads to pain about two hours after meals, and which is relieved by taking food; this is the stage in which the term hyperchlorhydria may be properly applied.

If the disease persists, the overproduction of acid gastric juice from being intermittent becomes constant, and it is then accompanied by a greater or lesser degree of pyloric spasm associated with pyrosis and at times with vomiting. After the persistence of pyloric spasm for some time, dilatation of the stomach with stasis supervenes, a condition which is known as Reichmann's disease.

The first stage of simple hyperchlorhydria is often met with even in young men otherwise in good health, and should always yield to a diet of milk with a certain amount of animal foods; but all chemical excitants of gastric secretion, such as salt, pepper, mustard, spices, pickles, and alcohol should be avoided, as should sugar and sweet things, as well as acids; though fats which have a resisting influence on gastric secretion may be freely partaken of. Bitters before and acids after meals should not be given. Calcium carbonate about two hours after meals, with magnesia if there be constipation, has been found useful. A dose of Carlsbad salts in hot water before breakfast is to be recommended.

In the later stages, when spasm of the pylorus with dilatation of the stomach and stasis are present, complete rest to the digestion by giving milk diet for a time is advisable, and if a little carbonate of soda be added to the milk it will not clot in the stomach and will be more readily digested. Later, gastric lavage and a dry diet will be useful. But if after a fair trial of medical and general treatment the symptoms persist and the dilatation continues, gastro-enterostomy ought to be considered, as it is capable of giving complete relief.

Atonic Dyspepsia.—In the atonic form of dyspepsia, when the functional power of the gastric secretion is diminished and there is gastric atony, dyspeptic symptoms characterized by pain and discomfort after food, with flatulency, are almost constantly present, and there are usually found neurasthenic symptoms with obstinate constipation. Here the stimulants of gastric secretion should be freely taken in the shape of soup, meat extracts, salt, and other condiments, while meat and other foods that make a great demand on the solvent powers of the gastric juice should be presented in such a form that they can be rapidly passed on.

Seeing that the motor functions are feeble, the meals should be small and bulky foods should be avoided. Alcohol has in this class of cases a distinct dietetic value, both as a stimulant of the muscular fibers and as an excitant of secretion. Strychnin before meals and acids after food have a beneficial effect. But, when the functional power of the gastric secretion is seriously diminished, the gastric muscular fibers are greatly enfeebled and the stomach is dilated and unable completely to empty itself, if general treatment with gastric lavage has been thoroughly and patiently tried and found incompetent to bring about a cure,

surgical treatment in the shape of gastro-enterostomy should be seriously considered, as it is capable of affording great relief, and with the improvement in nutrition the neurasthenic symptoms and the constipation usually disappear.

It must not be lost sight of that in cases of dilatation of the stomach where nervous symptoms predominate and where the dilatation is not dependent on obstruction, the results of surgical treatment are not immediately so satisfactory as when dilatation is due to stricture of the pylorus. This is probably in consequence of the neurasthenia, which still requires careful attention for some length of time, but also because the secretory apparatus and muscular wall of the stomach take a considerable time to recover their tone and functions. Although the stasis may have been corrected by gastro-enterostomy or some other operation, medical and general treatment must still be continued, otherwise the patients will be little better off from any surgical treatment.

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CHAPTER L.

SURGERY OF THE LIVER, THE GALL-BLADDER, AND THE BILIARY DUCTS.

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I. Surgery of the Liver.

INTRODUCTION.

The primitive intestinal tube is composed of the "fore-gut," the "mid-gut," and the "hind-gut."[1]

From the fore-gut we get the back wall of the pharynx, esophagus, stomach, liver, and pancreas, and the duodenum down to Ochsner's muscle,[2] which lies just below the common duct, near the junction of the second and third portions of the duodenum. For a short period early in development a thickening of the mucosa closes the bowel at this point. The derivatives of the fore-gut are concerned in the preparation of food for absorption.

From the mid-gut we get the terminal duodenum beyond the common duct, the jejunum, ileum, cecum, ascending, and most of the transverse colon;[3] all of which are concerned in the absorption of food. Nearly all of the carbohydrates and at least 90 per cent. of the proteids are absorbed in the small intestine, while the fluids are, to a large extent, taken up in the cecum.[4] A small part of both fluids and solids are, however, absorbed in the transverse colon.

From the hind-gut we get the distal portion of the transverse and descending colon, sigmoid, and upper part of the rectum, organs concerned in the storage function.

The inferior extremity of the fore-gut,[5] in the early development, lies in the cavity which is eventually to become the lower part of the thorax. It is sustained by two folds called the anterior and posterior mesogastrium. About the third week there projects forward into the anterior mesogastrium a diverticulum of the fore-gut at the part which is to become the upper duodenum. This diverticulum is composed of hypoblastic tissue, which extends up into the mesoblast at the transverse septum of His.[6]

From the extremity of this diverticulum[7] two buds are developed, from which are formed the entire liver, including the hepatic ducts. The right and left primary hepatic ducts unite to form the main hepatic duct. The gall-bladder and cystic ducts are formed from the common duct, which is a direct extension of the duodenal tissue.

The liver has considerable power of regeneration. In the dog one lobe can be removed completely and the remainder will rapidly develop hepatic tissue, both from the cells and hepatic ducts, until the proper weight and size is restored.[8]

The liver is the largest gland in the body; at the fourth month of gestation it is one-tenth of the body-weight. At birth it is one-twenty-fourth of the body-weight, but on account of the change in circulation at that time, its blood supply is much reduced, so that its growth is

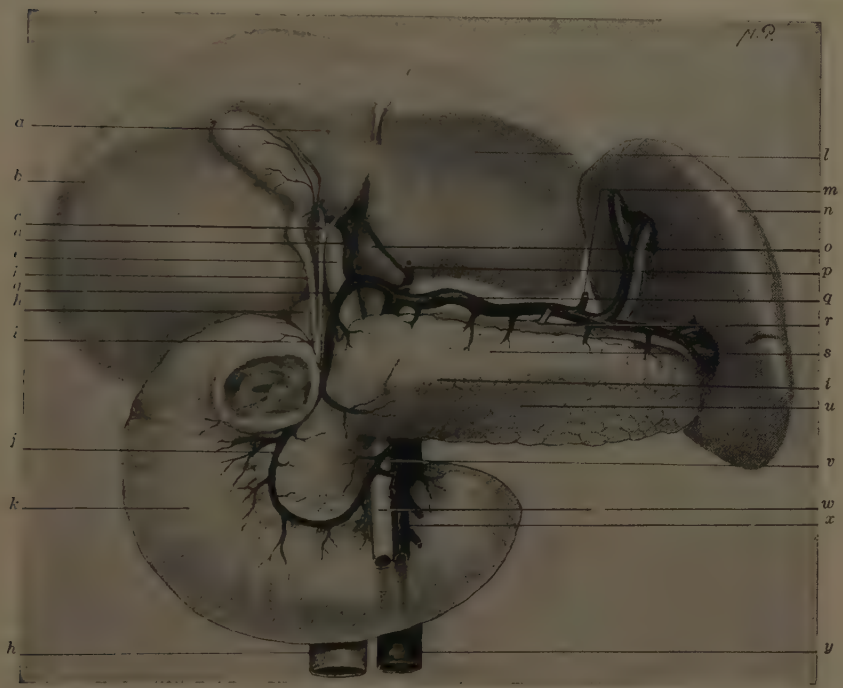

FIG. 504.—DISSECTION OF ADULT LIVER, PANCREAS, SPLEEN, AND DUODENUM WITH VESSELS, TO SHOW STRUCTURES CONCERNED IN THE FORMATION OF THE FORAMEN OF WINSLOW. (G. S. Huntington.)

a, Quadrate lobe; *b*, right lobe; *c*, hepatic duct; *d*, hepatic artery; *e*, portal vein; *f*, cystic duct; *g*, gastroduodenal artery; *h*, *h*, postcava; *i*, common bile-duct; *j*, superior pancreaticoduodenal artery; *k*, duodenum; *l*, left lobe; *m*, left gastro-epiploic artery; *n*, spleen; *o*, Spigelian lobe; *p*, gastric artery; *q*, splenic artery; *r*, splenic vein; *s*, pancreas, ventral surface; *t*, pancreas, ventral margin; *u*, pancreas, caudal surface; *v*, inferior pancreaticoduodenal artery; *w*, superior mesenteric vein; *x*, superior mesenteric artery; *y*, aorta.

less rapid. In the adult the liver weighs between 50 and 60 ounces, and is relatively somewhat larger in the male than in the female, being one-thirty-sixth of the body weight in the male to one-fortieth in the female. Only two of the five lobes, the right and the left, have surgical importance. In many persons a long tongue-like process of the right lobe in the vicinity of the gall-bladder projects downward, and is usually called "Riedel's lobe." This is sometimes called the corset lobe, and is supposed to be due to tight lacing. It is quite common, however, among those who have never worn tight corsets.

The right lobe of the liver in a thin person can be felt just below the costal margin on deep inspiration. The left lobe can nearly always be palpated between the midline and the left costal arch. The pleura extends downward to within about 2 inches of the free margin of the ribs. Thus, while separated by the diaphragm, it covers the most of the upper surface of the liver. In a very large part of its extent the liver is covered by peritoneum which forms folds (suspensory and other ligaments) which anchor it in position, but which allow considerable latitude of motion when acted upon by the diaphragm. Relaxation of these supports permits of undue movability. Immediately beneath the peritoneal investment is a thin fibre-elastic membrane,

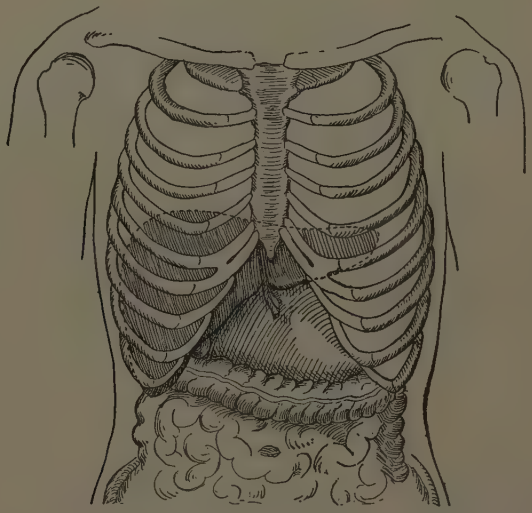

FIG. 505.—ANATOMIC DRAWING SHOWING RELATIONS OF LIVER AND GALL-BLADDER.

to which is closely connected the peritoneum and liver substance, called "Glisson's capsule."

The liver receives its arterial supply from the hepatic artery, which is a branch of the celiac axis. It is interesting to note, in connection with the chemical influence of hormones and secretin[9] on the digestive function, that the derivatives of the primitive fore-gut, the stomach, upper duodenum, pancreas, and liver, get their blood supply from the same source.

The hepatic artery runs in the gastrohepatic ligament above the common duct, close to the portal vein; the latter vessel carries the venous blood from all the organs concerned in digestion and absorption to the liver before it is permitted to enter the general circulation. The blood-pressure in the liver is extremely low, and slight pressure checks bleeding. The portal vein divides into the two primary vessels, the right and the left. The right is larger and shorter and is a direct continuation of the portal vein, so that embolic material carried to the liver most often involves the right lobe. The hepatic ducts follow the

same course. The right primary hepatic duct is a direct continuation of the main hepatic and common ducts, so that stones passed from the gall-bladder into the deep ducts, if they travel upward, usually pass into the right duct. For the same reason duct infections are usually more extensive in the right rather than in the left lobe.

The liver has many functions. The one which concerns us more particularly, surgically, is the formation of bile. This is an alkaline fluid which contains a certain amount of waste solids and pigments from worn-out cells, from 20 to 30 ounces being formed in twenty-four hours. Healthy bile contains a moderate number of bacteria[10] which have been carried to the liver and are excreted with the bile. Adami and Ford[11] have shown that leukocytes pass out onto the free surface of the mucous membrane of the upper jejunum and duodeum and pick up particles of fat and bacteria. These are carried into the neighboring lymphatic glands and destroyed. Many of these bacteria, however, find their way into the liver, where they are destroyed or greatly attenuated, and excreted with the bile. It is this attenuated bile infection, especially from the colon group, which underlies gall-stone disease, and the pigments of the slaughtered bacteria, which give rise to the little areas of pigmentation often found in the liver. When the bile passes out through the common duct into the duodenum, it stimulates and aids pancreatic digestion. In the cecum the fluids are re-absorbed, while the bile pigments have a stimulating effect upon the function of the large intestine, and are excreted with the stool. The secretion of bile, like the formation of pancreatic juice,[12] is dependent upon chemical reactions rather than nerve impulse, although both organs receive some branches from the vagus. The most sensitive area about the liver is in the vicinity of the common duct and about the neck of the gall-bladder. These receive terminal filaments from the eleventh and twelfth dorsal and first lumbar nerves, which extend out upon the diaphragm. This nerve association accounts for the diaphragmatic spasm of gall-stone colic, and shows the reason for the disturbance of the diaphragmatic respiration, at times, even under deep anesthesia when operating in this region.

ANOMALIES AND MALPOSITIONS.

Among the rare conditions is a complete transposition of the viscera in which the right lobe and gall-bladder will be found on the left side. This is interesting because under such circumstances it sometimes happens that gall-stones give rise to urgent symptoms requiring operation. Such cases have been reported by Billings,[13] Carl Beck[14] and one case in our experience. Downward displacements are the most common and may be the result of thoracic disease, such as emphysema and pleurisy, or from disease of the spine with deformity. Upward displacements are found in congenital and acquired diaphragmatic hernia[15] (Binnie, Operative Surgery), also in ascites and abdominal growths.

Hepatoptosis, or a liver movable in a downward direction, is much more common than has been thought. Einhorn[16] has called particular attention to the frequency of this form of displacement. Extreme mobility is occasionally seen, in which the entire liver descends into the pelvis, or may be rolled about the abdomen. A movable liver with an over-hanging corset lobe is sometimes mistaken for a movable right kidney, tumor of the colon, pylorus, gall-bladder, or pancreas. Careful palpation will show the sharp edge of the liver, which can be bent sufficiently upon itself to give a distinct sensation, as it slips by, and will obviate this mistake.[17]

A considerable number of livers with different degrees of prolapse have been operated upon with more or less success. Cases are reported by Jonas[18] and others. Terrier and Auvray[19] have collected 15 cases with 11 cures and 1 death. The operations for restoration have usually consisted of shortening the suspensory ligaments, fastening the margin of the liver to the parietal peritoneum and overlying muscles, with heavy silk sutures placed in mattress form, and by attaching the gall-bladder to the upper angle of the incision. Marchant scarifies the dome of the liver to favor adhesions. Depage combines hepatopexy with excision of part of the abdominal wall to overcome relaxation. A large majority of patients suffering from hepatoptosis will also be found to have abdominal ptosis (Glénard's disease), and rarely to require operative treatment.

INJURIES TO THE LIVER.

Injuries to the liver are usually the result of direct violence, stab and gunshot wounds being the most common varieties. Crushing injuries of sufficient force to lacerate the liver are usually complicated with other serious injuries which result in death. A number of cases of mild degree have been reported which have gone on to formation of large hematomata and secondary cysts, due to partial absorption of the blood clot, or which have become infected, followed by the formation of hepatic abscesses. It sometimes happens that through rupture of the liver, much blood and later bile escapes into the peritoneal cavity, giving rise to ascites, at first bloody, and later of almost pure bile.[20] Formerly a number of these cases recovered under aspiration, but the rule was the formation of extensive adhesions, infections, and death, the non-operative mortality being 85 per cent. This was especially true where the gall-bladder was perforated.

Stab and gunshot wounds and other injuries of the liver, complicated by open wound, should be treated by prompt laparotomy with thorough cleansing of the injured surface and by gauze packing. If the hemorrhage is sufficiently serious, the introduction of catgut sutures in mattress form, especially as an aid to compressing the gauze against the bleeding surface, will usually be found effective. The blood is under very slight pressure in the liver, and careful packing is usually efficient both in checking the hemorrhage and furnishing the necessary drainage.

Edler[21] calls attention to the fact that if hemorrhage proves fatal, it is usually within twenty four hours, while cases which survive this period usually develop jaundice. Subcutaneous injuries of the milder class may recover. They should be watched carefully, and if there is a probability of bleeding going on into the abdominal cavity, exploration should be prompt. The results of operation, as published by Edler in 1887, was an average mortality of 66 per cent., while Terrier and Auvray, in a later series show a mortality of only 30 per cent. Tilton,[22] in the period from 1895 to 1905, shows an average mortality of 44 per cent.

SURGICAL INFECTIONS OF THE LIVER.

Abscess of the liver can be divided into three groups: first, multiple abscesses; second, pyogenic abscess; and third, amebic abscess.

Multiple abscesses are usually embolic in character and have resulted from infection of the portal vein through some of its radicals. This variety is most often seen as a suppurative pylophlebitis. In the large majority of cases the primary lesion is appendicitis,[23] or an ulceration in the stomach and duodenum or in the intestinal tract, especially rectal ulcers and infected hemorrhoids. Rarely an acute pancreatitis is the primary disease. In the course of general pyemia the liver is often involved, and, under such circumstances, the initial infection may be in any part of the body and be distributed to the liver through the arterial system. A large variety of bacteria are present in disseminated hepatic abscesses and death from pyemia is the ultimate outcome.

Multiple abscesses may also occur in the course of septic cholangeitis in which the infected liver ducts, through obstruction and lack of drainage, rupture and permit bacterial invasion of the liver substance. The suprahepatic abscesses, which form between the liver and peritoneum, are undoubtedly caused by lymphangeitis. Multiple abscesses usually develop suddenly with a temperature of the hectic type, and are marked by rapid and progressive emaciation, chills and sweating, abdominal distention, and, in the later stages, by great prostration, diarrhea, etc. Leukocytosis is present and the abscesses contain pus. In the later stages, especially if the condition is prolonged, the pus may be found sterile. In protracted cases the toxins may give rise to vascular or renal degenerations. A moderate amount of jaundice is frequently seen.

The **symptoms** are much more acute than in single abscess, and although the liver, especially the right lobe, is enlarged, there is not the tendency to the formation of a localized tumor seen in solitary abscess. In the diagnosis, a local source of origin, such as appendicitis, infected hemorrhoids, or some ulceration in the gastro-intestinal tract, is first to be looked for. The second feature is the development of pyemia, and the third evidence that the liver is involved.

Treatment.—Surgery does not offer any prospect of relief, although a few cases have been reported by Davis[24] and others in which the

liver has been freely incised and packed, opening as many abscesses as possible. Treves[25] reports one successful case in which very little was done beyond exploration. In multiple abscesses the only hope would appear to be from serum-therapy. The work of Wright of London, with opsonins, is evidently along the right line.[26]

Localized hepatic abscesses are divided by Kartulis[27] into two groups: those due to any pyogenic microörganisms, the source of infection being the alimentary tract, and amebic abscess.

Second, **pyogenic infection of the liver** may give rise to localized abscess, caused by any one or more of the ordinary group of pus-forming bacteria. The pus exhibits the usual characteristics. In some cases, however, destruction of the liver-tissue is rapid and the liver-débris, with a moderate amount of blood, may give a chocolate appearance to the contents of the abscess. Such localized abscesses may have their origin in traumatism. Indirect injuries, *e. g.*, severe contusions, may rupture the liver subperitoneally and give rise to a hematoma under Glisson's capsule, and this hematoma may become infected. Gunshot or stab wounds may directly infect the liver.

Ulceration from foreign bodies in the stomach or intestine, such as needles and fish bones, have occasionally been the cause of hepatic abscess. Superficial or deep infection of the liver may be the result of gall-bladder infections, especially when stones pass by ulceration through the gall-bladder into the neighboring liver tissue, and give rise to localized abscess (Kehr[28] and Robson[29]).

Under peculiar circumstances, non-amebic dysentery and the whole group of infections which so frequently result in multiple abscesses may be lodged sufficiently close together in one lobe of the liver to form one large abscess with communicating pockets. Suppuration of an echinococcic cyst very frequently gives rise to false hepatic abscess. In this entire group some degree of leukocytosis is present, excepting in old encapsulated collections of pus.

The third form is **tropical abscess of the liver* due to ameba,** one of the protozoa.[30] In 70 per cent. of these cases the abscess is single. In a considerable percentage of the remainder, where more than one abscess is present, they are located closely together and often communicate. According to McLeod, in 97½ per cent. amebic dysentery is the antecedent factor. Kieffer[31] has demonstrated that in the army the amebic dystentery itself may have been latent or transient, and that the abscess may not follow for as long as two years after the attack. It is also shown that occasionally amebæ have been found in the colon without symptoms. There has been a good deal of discussion as to the part played by the ameba in the production of these abscesses, as in a percentage of cases pyogenic bacteria are found in connection with the ameba, but only for some days after opening the abscess. In a good many cases, however, no pyogenic micro-organisms are to be found, and in practically all of the cases of tropical abscess

* For full description of Tropical Abscess see chapter on Tropical Diseases, Vol. IV.

the ameba can be discovered in the scrapings from the wall of the abscess cavity. Pus from the liver seldom resembles pus from any other part of the body. It is usually thick from liver-débris and of a reddish-brown chocolate color, and often contains some blood and streaks of yellow pus. Occasionally it is offensive in odor.

In the after care it is noticed that the pus is thick and mucoid, covering the area about the incision rather than being absorbed by the dressings. No leukocytosis is present, unless there is mixed infection. Amebic abscesses are by no means confined to the tropics; they are found quite frequently in the hospitals of sea-coast cities, but the history will show that within two years the large majority have had a more or less prolonged residence in tropical countries.

White men who have suffered much from exposure and malaria, and especially those who are addicted to alcohol, are the most liable to this disease.

The chief **symptoms** of localized abscess, whether pyogenic or amebic, are summed up by Kieffer under four heads: fever, sepsis, enlargements of the liver, and pain. In studying these separately we find that the fever is variable and not typical, ranging from subnormal to a few degrees above, and is often accompanied by chills and sweats, especially at night.

In those due to the ordinary pyogenic micro-organisms leukocytosis is present. Some cases, however, of both varieties, are so thoroughly encapsulated as to give but comparatively little systemic symptoms, and sepsis in these cases may not be a marked element. The rule is, however, that there is general emaciation, progressive weakness, loss of flesh, and, in the later stages, toxic diarrhea. The tongue remains remarkably clean, but vomiting is a frequent symptom in the early hepatitis. Enlargement of the liver is always present and is the cause of certain marked symptoms. From anatomic reasons the right lobe is the one usually involved. If the abscess projects downward it may be felt below the costal margin. The intercostal space over the tumefaction may disappear, and in the later stages, the subcutaneous tissues often become edematous. If the enlargement is upward and encroaches upon the diaphragm a convulsive cough is present, which becomes extremely annoying and is particularly marked at night. Pain in the early stages is indefinite, but later becomes localized as tumor develops and the abscess approaches the surface. A perihepatitis then develops, which is quite typical of regional peritonitis, and may be useful in indicating the line of safe approach. Some cases have so little pain that they are merely uncomfortable. Usually, the right rectus muscle maintains a protective rigidity, and the patient avoids lying on the left side.

In the **differential diagnosis** multiple embolic abscesses should be eliminated; also certain cases of pneumonia, resulting in localized empyema or abscess of the lung, should be differentiated. Local abscess from rupture of a suppurating gall-bladder and subdiaphragmatic abscess from appendicitis, or perforating gastric or duodenal

ulcer, may give rise to diagnostic difficulties. In hepatic abscess, or the hepatitis which accompanies it, the spleen is small; should it be large, it points to pylephlebitis as a probable complication. About 28 per cent. of liver abscesses rupture spontaneously, and 56 per cent. of these do so in an upward direction. However, if a localized abscess, whether hepatic or not, exists from any cause, operation is indicated for its relief.

Left to themselves, hepatic abscesses may last for months, and occasionally with so few symptoms that a sudden expectoration of pus ruptured into a bronchus or an evacuation of pus per rectum may be the first symptom. Rupture into the pleural or the abdominal cavity may take place, necessitating immediate intervention, or death results. Occasionally abscesses will present subcutaneously between the ribs or in the loin, and they have been known spontaneously to perforate externally.

The **surgical treatment of localized hepatic abscess,** whether pyogenic or amebic, consists in evacuation by means of incision at the earliest possible moment. While many cases have been reported by Cantlie[32] in which aspiration and syphonage (Manson's method) have resulted in cure, such means must be looked upon as unsurgical and uncertain, and should be attempted only by those who are unskilled in surgical operations or in the face of bad surroundings when the condition of the patient renders it impossible to transport him to a well-equipped hospital.

Exploratory aspiration of an hepatic abscess should not be made until all the preparations necessary for immediately opening and draining the cavity are present. If the needle finds its way to the pus-sac it should not be removed until drainage is effected. It is surprising how many exploratory aspirations have been made without disclosing a large abscess, and how many times, when pus is shown by aspiration, and the needle removed, at operation undertaken within a few hours it has been impossible to find the abscess.

Three routes are possible for effecting entrance into the abscess cavity: (1) abdominal incision; (2) transpleural incision; (3) combined abdominal and transpleural incision.

1. *Abdominal Incision.*—An incision is made into the peritoneal cavity at a situation protected by adhesion, if possible, until the liver is exposed at the point of election; after proper gauze protection of the abdomen, the abscess is located with a needle or grooved director and a small incision into it made with a knife; the opening is rapidly dilated with a pair of forceps and the finger. After evacuation of the pus and removal of the loose necrotic tissue, the cavity is drained with a tube and gauze packing. The gauze protection can then be removed and a much smaller amount introduced, as, if the abscess has been thoroughly evacuated, there will not be any considerable escape of septic material in the few hours necessary for adhesion to form. The after-care is very simple. Drainage is continued, with or without packing, until suppuration ceases and cicatrization takes place. Irrigation is useless and

often harmful. In some cases without peritoneal adhesions a two-stage operation has been recommended. The liver is exposed and the vicinity packed with gauze, waiting forty-eight hours for adhesion to form before opening the abscess. This method has little to commend it.

2. *Transpleural Operation.*—If the abscess presents upward a transpleural operation may be necessary, but this should be avoided if possible. As a rule, with the finger in the pleural cavity as a guide, the abscess can be located, and opened in some situation below the diaphragm. If transpleural opening is decided upon and there are no adhesions, packing with gauze and waiting for formation of adhesions is good practice, as the pleura has much less power of resistance than the peritoneum. In experienced hands a complete operation may be immediately performed by suturing both layers of the pleura to the diaphragm with catgut on a curved needle, after preliminary resections of two or more inches of several ribs; in this way a safe approach to an hepatic abscess is obtained. If necessary, the diaphragmatic and visceral peritoneum may be sutured in a similar manner, if no peritoneal adhesions are present. Should the infection have already involved the pleural cavity, as by rupture, free incision and tube-drainage of both the pleural and abscess cavities is necessary after enlarging the place of diaphragmatic perforation.

3. *Combined Abdominal and Transpleural Operation.*—Through a straight incision the abdominal cavity is opened; the incision carried upward; sections of ribs removed; the diaphragm incised and an attempt made to push the pleura upward by gauze sponging. If this cannot be accomplished, the pleural layers are sutured to the margins of the diaphragmatic incision and, after inserting gauze protection, the abscess is opened, evacuated, and drained. The abdomen is partly closed by careful suture of the unnecessary portion toward the lower angle. The entrance of air into the pleura in these operations has seldom given rise to serious trouble, but pleural infection is to be carefully avoided. The mortality, which was once 80 per cent., has been reduced by early and proper interference to between 20 and 30 per cent. and is constantly decreasing.

It is interesting to note that when large areas of the liver are destroyed by acute infection, the remainder will hypertrophy until the original weight is nearly restored.

HYDATID CYSTS OF THE LIVER.

Echinococci are the larvæ of the worm Tænia Echinococcus of the dog. It is a little cestoid worm about 4 or 5 mm. in length and consists of three or four segments. The terminal is the only one which is mature, and its length is about 2 mm. and the breadth 0.6 mm. The small head is supplied with four sucking disks and a double row of hooklets. It is a rare parasite in the dog, and it is stated by Cobbold that he has never seen a natural specimen in England. In the dog they show as small white shell-like bodies, adherent to the villi of the

small intestine. The terminal segment, when ripe, contains about five thousand eggs. These do not attain their development until they are deposited in the solid organs of various animals. Owing to the accidental ingestion of the ova in certain countries, as Iceland, man is occasionally the host. When one is swallowed, its covering is digested and the little six-hooked embryo burrows through the intestinal wall, muscles, etc. Although the parasite may develop in any one of many organs, in one-half or more of all cases it does so in the liver. It enters this structure through the radicles of the portal vein. Arriving in the liver, the hooklets disappear and the embryo is gradually converted into a small cyst, which presents an external laminated capsule and an internal parenchymatous layer which is called the endocyst. This little vesicle contains a clear fluid. When the primary cyst has attained a certain size, buds develop from the parenchymatous layer and these are converted into cysts within the original cyst, and are known as daughter cysts. The secondary cysts are soon set free; the original or parent cyst may then contain a considerable number of such daughter cysts. The daughter cysts undergo the same evolution, and granddaughter cysts are formed. From the granular layer of the cysts little outgrowths arise, which are known as scolices, presenting four sucking disks and a circle of hooklets. When such are transferred to the intestines of the dog, an adult tape-worm is formed. The liver surrounding the cysts shows the result of the irritation by developing a fibrous investment. As the size of the cyst gradually increases the liver-tissue becomes thin, and adhesion to the neighboring viscera is not uncommon from peritoneal irritation. The fluid of the cysts is peculiarly limpid, the specific gravity from 1.005 to 1.009; it does not contain albumin, rarely a trace of sugar, and when not too old one can find in it typical daughter cysts, scolices, and characteristic hooklets. In the course of time the liver-encapsulation may become so perfect that the living contents of the cyst die a natural death, and the cyst-fluid becomes converted into a mass of putty-like or granular material, which may become calcified. Perforation of the cyst into the abdominal cavity, pleura, a bronchus, etc. sometimes takes place. They have been known to perforate into the bile passages or even into the vena cava. Neisser, in 131 observations, reports 47 cases rupturing into the lung and pleural cavity; 46 into the stomach and intestines; 16 into peritoneum and 15 through the abdominal wall. As seen in America, almost all the cases are in the foreign born, natives of Iceland, the mountainous districts of Austria, and especially Australia. It is most common in cold climates where the dog occupies the same habitation as man, and particularly when this animal is employed for herding sheep, etc.[33] Of all American surgeons Ferguson[34] has reported, from among the Icelanders of Canada, the largest number of cases submitted to operation.

The **size and symptoms** are those of pressure, and depend upon the situation of the cyst, its size, nearness to the surface, and the amount of disturbance of neighboring viscera. A hydatid cyst of the

liver usually forms a tumor of considerable size, which often projects in the epigastric region, has rather a tense feeling, and if not firmly held by adhesion, presents an obscure sense of fluctuation. When quite superficial, hydatid fremitus may be elicited upon palpation. This is a peculiar vibration or trembling movement to be felt when stroking the surface of the tumor. Unless some of the accidents referred to occur, apart from the enlargement of the infected portion of the liver, the symptoms may be comparatively slight.

Brieger[35] says that upon rupture of the cyst urticaria is often developed. Suppuration is the most common accident, and a picture of general sepsis is rapidly produced, which the tumor and local symptoms at once show to have its center in the liver. The presence of the tumor, previous to the development of acute symptoms, is valuable in the differential diagnosis. Syphilis and cancer may be simulated very closely by hydatid disease of the liver. A syphilitic gumma is firm and not fluctuating, and the symptoms are more severe than in uncomplicated hydatid cysts and less severe than suppurating cysts. The clinical course of hydatid disease usually differentiates it from cancer. In one case of ours, however, even after opening the abdomen, the picture was so similar to that of cancer that it was only lack of a primary source for the apparent secondary liver metastasis, and the freedom from glandular involvement, which led to an exploratory puncture of the suspected tumor.

Hydatid cysts of the right lobe may extend so high as to simulate pleuritic effusion.

Aspiration with a fine needle gives the characteristic opalescent fluid, but such diagnostic puncture should not be made until all the preparations for operative interference are complete. While a number of cases have been reported in which simple aspiration has resulted in cure, such practice has little to commend it. It has all the dangers of a blind and unsurgical procedure and introduces an unnecessary element of risk, both immediate and remote.

Operations for hydatid cyst may be divided into (*a*) incision and drainage, and (*b*) incision and enucleation of the sac.

(*a*) Incision and drainage is the operation which is ordinarily performed and is simple. The abdomen is opened by a vertical incision over the most prominent part of the tumor, and the peritoneal cavity carefully walled off. Some surgeons of the older school prefer to pack the entire exposed surface of the liver with gauze and wait until adhesion forms before opening the cyst. This practice has little in its favor, as it limits the sphere of future operation and does not allow of complete work. After protecting the cut edges of the abdominal incision with gauze, to prevent echinococcus infection, an aspirating trocar connected with rubber tubing is introduced into the cyst at the point where it comes closest to the surface of the liver, and as much as possible of the fluid is evacuated. The incision is now enlarged, the trocar is withdrawn, the cavity is explored with the fingers, and as much as possible of the cyst contents removed. As the cyst contracts it becomes

an easy matter to detach the daughter cysts and remove the endocysts. The cavity is packed with sterile gauze, and the incision in the liver carefully united to the peritoneum with catgut sutures. When this "marsupialization" has been accomplished, a large, dry dressing is applied, which ordinarily will not need to be disturbed for from four to eight days. Repacking at intervals is employed until the cyst contracts. An ordinary rubber drainage tube in addition can be employed to advantage, and in small cysts will suffice.

(*b*) Incision and enucleation of the cyst, as carried out by Knowsley Thornton,[36] is a much more complete operation. The proceeding is similar to the operation just described, except that the abdominal incision is larger and the incision in the liver is made as large as is compatible with safety. The edges of the wound in the liver are covered with gauze, and retraction of the cut margins of the liver is made to check bleeding.

The contents of the parent cysts are rapidly removed. Following this, the parent cyst itself is enucleated largely by gauze sponging. The hemorrhage is comparatively slight and is mostly capillary oozing. In the typical method, the cavity left in the liver as well as the external wound is completely sutured. In cases operated upon by Thornton, Bond, and Delbet all of the patients recovered, but suppuration followed in about 10 per cent. of them. We have practiced the Thornton, or what is known in France as the Delbet operation, in all of the non-suppurative cases which have come under our observation, with the exception that when the cysts are of any size it has been difficult to entirely coapt the large surface, which we always attempt to do with fine catgut on a curved needle.

If it is impossible to close the liver-cavity, a few strips of rubber tissue are introduced and brought out through the external wound by a separate stab incision. We are rather inclined to believe that some form of drainage in hydatid cysts of any size or any depth in the liver is a proper procedure, as it sometimes happens that bile-stained fluid will escape for some days due to division of the smaller bile ducts. Drainage by means of rolls of rubber tissue is less liable to be followed by secondary pyogenic infection or slow healing than gauze or tube drainage.

In incising suppurating cysts partial enucleation and drainage is usually employed, but even in these cases usually the entire cyst can be enucleated.

If the cyst presents high up in the right lobe, in the part completely protected by the ribs, resection of parts of two or three ribs may be practiced, and the operation completed as before. If it is necessary to make a transpleural operation, it is wise to suture with catgut on a curved needle both layers of the pleura to the diaphragm before opening the cyst, and here, if at all, might be employed the two stage plan of packing with gauze and waiting forty-eight hours for adhesion to form before evacuating the cyst.

In all cases the wound surfaces should be carefully protected from the hydatid fluid.

Devé and Quénu[37] have proved beyond question the possibility of hydatid infection of these raw surfaces. They have recommended destruction of the living organisms in the cyst wall by antiseptic solutions of formalin or corrosive sublimate previous to enucleation of the parent cyst.

Liver parasites, other than echinococcus, are occasionally found in the liver of animals, and even in that of man in some tropical countries. They belong to the Distomata of the family Trematode.

TUBERCULOSIS OF THE LIVER.

Tuberculosis of the liver is a rare malady. When found, it is usually part of a generalized miliary tuberculosis. The tubercle bacilli are carried to the liver most frequently through the portal circulation from some local focus in the radicles of the portal vein. Infection may also occur by way of the hepatic artery, or more rarely through the lymphatics against the normal flow. A few cases have been reported in which a solitary abscess has existed, and after evacuation by operation the patient has recovered and remained well. Mayo Robson[38] reports a case in which, two years after such an operation, the patient was in most excellent health. The so-called "solitary" tuberculous abscess is not often single. Usually several such exist, although seldom discovered during life. If they can be diagnosticated, they may be subjected to operation with prospect of cure. The treatment should consist of evacuation, careful sponging out of the caseating mass, and the application of a 1 to 500 solution of tincture of iodin, or pure carbolic acid followed by alcohol. The cavity should then be dried and dusted with sterile iodoform, or 1 or 2 drams of sterile 10 per cent. iodoform emulsion in glycerin may be introduced, and the wound closed without drainage.

ACTINOMYCOSIS OF THE LIVER.

For a general description of the development and character of the ray fungus, the reader is referred to Vol. I., p. 516.[39]

Actinomycosis, occurring in the liver, must be conveyed to it from an absorbent surface, such as the intestine, or it may have spread by continuity of tissue. In 40 cases of hepatic actinomycosis the growth was derived from the alimentary tract in 20, by continuity of tissue in 8, and by metastasis in 12. The liver is enlarged, but the honeycomb abscesses are usually limited to one area with possibly a few scattered colonies. Large masses of the liver, and adjacent tissues as well, may become involved and the disease spread to the diaphragm, lung, or the kidney. The clinical aspect is that of abscess. The diagnosis may be confused with syphilis and tuberculosis, but examination of the pus should show the characteristic ray fungus or actinomyces colonies. The prognosis depends upon a recognition of the disease, its extent, and the effect of treatment. The administration of iodid of potassium in

large doses, as recommended by Thomasson, is nearly as effectual as in tertiary syphilis, but is slower. Bevan recommends the internal use of cupric sulphate in doses of from ¼ to 1 grain three times a day, and irrigation with a 1 per cent. solution of the same.[40]

SYPHILITIC DISEASE OF THE LIVER.

The idea that syphilis affected the liver is said by Frerichs[41] to be as old as the history of syphilis itself, but it was not until Dittrich, in 1849[42] and Samuel Wilkes, in 1850,[43] described gummata in the internal organs that the distinction was made between this disease and malignant growths. Syphilitic tumors of the tertiary stage are the only ones in the liver that have surgical interest. Gummata of the liver are often mistaken for carcinomata, and when situated in the region of the gall-bladder, may, for some reason, give rise to attacks of colic resembling that of gall-stone disease. The spirochaeta reach the liver through the arterial current or by way of the portal circulation. A granuloma is formed, which becomes surrounded by a fibrous capsule, and in time loses its blood supply through endo-arteritis. A gumma, on section, presents a focus of caseation, surrounded by granulation tissue, which later becomes converted into a firm cheese-like mass.

The surgical recognition of these tumors is very important, as exploratory abdominal incision is frequently made, and, from the appearance, malignant disease is diagnosticated or an unnecessary resection of the infected portion of the liver may be undertaken. Four times we have found syphilitic gumma in connection with cholecystitis, twice without stones. In the last two cases, the gall-bladder contents were carefully examined for the spirochaeti, but it was not found. In all of these cases the syphilitic tumor lay in the adjacent border of the liver, and removal of sections showed typical gumma, which disappeared under specific treatment.

Syphilitic cirrhosis of the liver has very little surgical importance. The contracted areas resemble stellate scars and usually give rise to deep contractions. The intervening hepatic substance is comparatively healthy in appearance and the nodes that are formed are usually of large size, in this respect differing greatly from the ordinary hob-nail forms of cirrhosis.

CIRRHOSIS OF THE LIVER.

Hypertrophic cirrhosis (Hanot) with jaundice has been treated experimentally by some French investigators by drainage of the gall-bladder through cholecystostomy. As would be expected from the pathologic nature of the disease, the results have not been favorable.

Banti's disease is the name given to a rather indefinite combination of a primary splenomegaly, with secondary cirrhosis of the liver and usually some jaundice. It is most common in children and young adults.

A small number of these cases have been subjected to operation. In a few the spleen has been removed; in others, the gall-bladder has

been drained. While temporary improvement has been reported, there is nothing in the nature of these maladies or in the ultimate results of the cases operated upon to lead us to hope for much from surgery. In the simple cases of splenic anemia, before the development of marked cirrhosis of the liver which constitutes Banti's disease, splenectomy has given fairly good results.

Atrophic vascular cirrhosis (Laennec), while not of itself surgical, may give rise to ascites, which in some instances may be greatly benefited by the Talma-Morison operation of epiplopexy.

Cases of atrophic cirrhosis of the liver may be divided into two groups; First, those due to alcohol. This group contains the large majority of all hepatic cirrhosis. The victims are usually middle-aged, but occasionally children are affected. The second group is small; while the liver-disease has the same appearance, an alcoholic history is lacking, and the process has been ascribed to the toxins of various diseases. This variety is most common in young adults.

The liver in vascular cirrhosis is typically hob-nail, and of small size. Its substance is composed of small, greenish-yellow islands, surrounded by grayish-white connective tissue. It was the yellowish appearance which induced Laennec to call it cirrhosis. Hilton Fagge,[44] in 1881, called attention to the fact that in a considerable number of accidental deaths in Guy's Hospital, in which the individual was apparently in the best of health, post mortem showed typical cirrhosis of the liver, and while not the first to show "compensatory circulation," his accurate and scientific work helped to place the subject on a sound basis.

Compensatory circulation is carried out by the following vessels:[45] 1. The accessory portal system of Sappey, connecting the portal with the epigastric and mammary systems. This is usually the cause of so-called "Caput Medusæ," a bunch of varices about the navel. Sappey's veins anastomose freely with the diaphragmatic veins and so unite with the vena azygos. Communication is also established in the gastro-epiploic omentum and about the gall-bladder, especially in the suspensory ligament of the liver. 2. By the anastomosis between the œsophageal and gastric veins. 3. The connection between the hemorrhoidal and inferior mesenteric veins. 4. The veins of Retzius, which unite the radicles of the portal vein in the intestines and the mesentery with the inferior vena cava and its branches.

Drummond and Talma, independently of each other, suggested surgical interference for the relief of the ascites in cirrhosis of the liver. Morison, who operated for Drummond, reported two cases in the British Medical Journal, Sept. 19, 1896.[46] Talma[47] did not publish his paper until Sept. 19, 1898, but the first operation at his suggestion, was made in 1889, and he both suggested and caused to be practiced epiplopexy.

The omentum contains very large vessels, and, on account of its movable character, is easy to attach to the abdominal parietes for the purpose of forming anastomosis between the systemic and portal

circulations. The good effect, according to Sinclair White,[48] lies not only in the increase in the circulation by reason of the supplementary channels of anastomosis which are formed, but also in that it increases the blood supply to the surface of the liver, whose cells possess considerable regenerative power. White, furthermore, points out that the removal of the ascitic pressure also has a good effect upon the liver function.

It is probable that the substitution of the extraperitoneal lymphatics for the over-worked lymph channels plays an active part in the improvement of these cases following epiplopexy (Mayo).

It has been the general experience that individuals with cardiac and vascular lesions, such as arteriosclerosis or kidney-degenerations, as well as those who are very advanced in years, are poor subjects for operative relief. Eighty per cent. of these cases have enlarged spleen and 22.5 per cent. have granular kidney. Persons who have developed tuberculosis are not suitable for epiplopexy. About 23 per cent., according to Pitt, and 30 per cent., according to Rolleston, of those who were examined post mortem, had tuberculosis, and nearly half of these, according to Kelynack, had tuberculous peritonitis. Young adults without alcoholic history, in our experience, have usually been favorable cases for operation.

Monprofit[49] shows a mortality of 28 per cent. in 224 collected cases. White compiles 227 cases of epiplopexy with a death-rate of 33 per cent., failure in 17 per cent., improved 13 per cent., and cured 37 per cent. The operation performed by Rutherford Morison is to fix the anterior surface of the omentum by numerous pin-point sutures to the opposed parietal peritoneum, which has been previously freshened by vigorous gauze rubbing. Schiassi of Bologna aims at placing the omentum outside the parietal peritoneum, between it and the posterior surface of the abdominal muscles in front.

We have usually carried out this latter procedure by making an incision on the right side over the liver, in a line with deep epigastric and internal mammary vessels so as to explore its surface. A second incision is made four inches below this through the rectus muscle, but not through its posterior sheath. The posterior sheath is extensively separated from the muscle and a portion of the omentum drawn out of the upper incision and, with a pair of forceps, pulled down into the pocket, bringing it directly in contact with the larger vessels. This can be repeated upon the opposite side and the intervening segment attached to the whole front of the parietal peritoneum, after the plan of Morison.

Supplementary procedures, such as freshening the superficial surface of the liver and the parietal peritoneum have some value. Displacement of the spleen behind the peritoneum has little to recommend it. Direct anastomosis between the portal vein and the inferior vena cava (so-called Ech's fistula) was unsuccessfully carried out by Vidol. In the experimental work on dogs the operation caused a tendency to uremia.

One mooted point in the after-treatment is the question of drainage. The English surgeons prefer tube drainage in the pelvis, the fluid being frequently removed, under strict antiseptic precautions, with a syringe, until it fails to re-accumulate. As the death rate from sepsis is about 18 per cent., a great many surgeons, especially in America, have avoided drainage, and if the fluid re-accumulates use repeated aspirations during the formation of the anastomosis, rather than permanent drainage. In 7 cases operated on by us we have not used drainage and had no deaths due to the operation. Two patients have lived more than three years.

TUMORS OF THE LIVER.

Benign solid tumors of the liver are exceedingly uncommon. Localized angeiomatous growths have been reported.[50] These tumors consist of a series of dilated blood vessels, the size of a walnut, or occasionally much larger. During operations for gall-stone disease we have seen a number of such tumors, sometimes distinctly circumscribed, sometimes forming an indefinite angiomatous enlargement of a considerable portion of the liver. None of these cases required operation, but during the removal of a gall-bladder which was overhung by such a mass, considerable difficulty was experienced in checking an accidental hemorrhage. This was finally accomplished by means of interlocking catgut sutures, which compressed a piece of gauze into the bleeding surface. Most of the reported resections of the liver for benign tumor have been for angeiomatous growths.

Simple cysts of the liver are described in the literature. Usually several cysts of small size lie in one lobe. True cystic disease of the liver has been reported.

Simple cysts of large size, containing several pints of clear fluid, are rarely encountered. We have met with 2 such cases, both in the right lobe The cyst had a capacity of 1 or 2 pints and contained clear watery fluid. In both instances it was with considerable difficulty that we were able to dissect out the thin cyst wall, largely by gauze sponging. The hemorrhage, which was quite profuse and capillary in character, was checked by a combination of catgut suturing and gauze packing, pressure being produced on the packing by the method of introduction of the sutures.

Adenomata of the liver are of rare occurrence. Usually, they are discovered post mortem as an innocent encapsulated growth of epithelial cells. Some are composed of hepatic cells. Others are derived from the bile ducts, while occasionally they appear to be fetal "rests" of adrenal or liver tissue. Interesting cases are described by Mohamed and Hale White.

Some of these tumors when single grow to a large size, and operative relief is urgent. Cases are recorded by Keen, Koenig, and Schmidt. Keen removed a cystic adenoma of bile-duct origin from a woman aged thirty-one years. Clinically, it was thought to be a floating kidney. The operation was in 1891, and she was well in 1899.

Multiple tumors are described by v. Hippel. Multiple adenomata occur at times in cases of cirrhosis. Cornil and Ranvier[51] consider these growths to be complications of cirrhosis. On the other hand Hanot and Gilbert look upon them as a special type of carcinoma.

Lipomata, or genuine fatty tumors are not met with in the liver.

Teratoma is a very rare condition in this organ. A primary tumor was reported by Musick,[52] and a secondary emplanted dermoid by Hulke.[53]

MALIGNANT DISEASE OF THE LIVER.

Primary carcinoma is a rare form of hepatic tumor, and appears in several forms. 1. Massive development, which involves a large section of the liver and has a well marked line of differentiation from the sound tissue. 2. Infiltrating, and 3, nodular growths, usually one primary growth with secondary nodules in the vicinity. Of this last variety, a case is reported by Keen[54] in which he removed almost the whole of the left lobe successfully. 4. This form is carcinoma with cirrhosis. This type is chiefly described by French writers. Hanot and Gilbert claim that one-third of the cases of primary carcinoma are of this type.

Secondary Carcinoma of the Liver.—This is the most common form of tumor of the liver, and is due to carcinomatous embolism from some point of primary cancer in the gastro-intestinal tract, especially from cancer in stomach and large bowel. In some cases anastomosis between the portal system and the uterine and ovarian veins carry infected cells to the liver from uterine carcinomata. Secondary carcinoma of the liver is, of course, entirely inoperable, yet it is of great surgical importance as a contra-indication to radical operation. No cancer of the abdominal portion of the gastro-intestinal tract should be operated upon, radically, without first examining the liver to see whether secondary deposits have already taken place.

The symptoms of hepatic embolic metastasis are peculiar. A sudden pain is developed in the region of the liver, usually with a chill and elevation of temperature; often slight jaundice is noticed. Ascites and jaundice are more frequent in secondary than in primary malignant disease of this organ. They are seldom seen in massive carcinoma. The local symptoms subside in a few days, but a tumor rapidly develops. Nodular masses can soon be felt projecting below the free border of the ribs. These increase in size and overshadow the primary disease. On exploration the liver will be found full of nodular masses, each being a point to which an embolus has carried the carcinomatous cells through the portal veins.

There is a class of cases in which carcinoma of the gall-bladder extends to the adjacent border of the liver, forming a well marked infiltration. These are occasionally operable. In 3 cases of this description in our hands, in which there was a well marked corset lobe, it was comparatively easy to resect the tongue of the liver with the

diseased gall-bladder. One case died from the operation, and 2 recovered, only to die of recurrence within the year.

Primary sarcoma of the liver is more rare than carcinoma. No case in which operation has been done has been reported. The lesions of congenital syphilis may be mistaken for the disease. It usually occurs as a massive tumor, a diffuse infiltrating form. One type is a multiple growth without a discoverable primary lesion. Sarcomatous tumors are usually secondary, having their source in sarcoma of other parts of the body. The secondary growth in the liver is much softer than carcinoma, sometimes it has a cystic or pulsating feeling, it is much more rapid in growth; this is especially true of the melanotic forms.

Another variety of tumor of the liver is due to metastasis of hypernephroma of the kidney. This is a fatal condition.

RESECTIONS OF THE LIVER.

Resections of the liver have not been attended with as many difficulties as would be expected. Out of 76 cases reported by Keen, 63 recovered. Hemorrhage, which has been the most important consideration, has seldom been the cause of death. In 52 cases related by Terrier and Auvray only two died from this cause. The experi-

FIG. 506.—EXCISION OF SECTION OF LIVER.
Method of checking hemorrhage by combined catgut suturing and gauze. Compression seen from above.

mental work of Gluck, Grimm, Kousnetzoff, Pensky, and Auvray have shown that resection of the liver by suitable methods can be accomplished with complete success.

The old-fashioned chain ligature of catgut has been resorted to to check hemorrhage. With a blunt needle and catgut interlocking sutures are placed through the entire thickness of that lobe of the liver which contains the tumor, completely circumscribing it. The tumor

is then cut away with the affected liver. The incision in the liver has often been made with the Paquelin cautery, although this is not necessary.

Jacob Frank has shown that if the edge of the liver is cut wedge-shaped, the projecting margins can be sutured together with catgut, thus checking the hemorrhage. Dudley Tait found that he could coagulate the vessels in the liver substance by the hypodermic injection of boiling water, so as to make a bloodless path around the proposed line of resection. Keen, in his celebrated case, slowly cut away the entire left lobe with a Paquelin cautery, closing the large vessels with a catgut suture on a needle as he came to them. Others have crushed the liver substance with heavy forceps, catching the bleeding vessels afterward on section through the path made by the forceps.

FIG. 507.—SAME AS FIG. 506 SEEN FROM BENEATH.

Personally, we have found the following combination simple and safe. If the portion to be excised is thin it is crushed with the forceps and then cut away with the knife, followed by a hot, moist compress, which is held on the bleeding surface. With catgut on a round needle the liver margin is quilted back and forth. As much as possible of the gap is closed by sutures, and a pad of gauze of sufficient size to fill the remainder is introduced and the liver firmly compressed upon this by catgut sutures which produce sufficient tension to check the hemorrhage. As it loosens the gauze is removed from the sixth to the twelfth day.

The older methods, in which portions of the liver were made extra-peritoneal, and after the introduction of hare-lip pins and sight elastic ligatures allowed to slough off, have little to commend them.

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II. SURGERY OF THE GALL-BLADDER AND THE BILIARY DUCTS.

INTRODUCTION.

During, approximately, the third week of development, a diverticulum sprouts from the duodenal end of the embryonic foregut, and pushes into the anterior mesogastrium as far as the transverse septum of His.[1] Two buds are developed from this diverticulum, which form

the liver and all of the hepatic ducts. The hepatic ducts drain into two primary divisions, right and left. The right is larger, shorter, and more direct. If stones are found choking the hepatic ducts, the right is most often the one involved.

The main hepatic duct is from three-fourths to one inch and a half in length, and extends from the union of the cystic and common ducts to the right and left primary divisions. The hepatic ducts have much less elastic tissue than the common duct, and in the liver substance itself the duct walls are thin and easily lacerated.

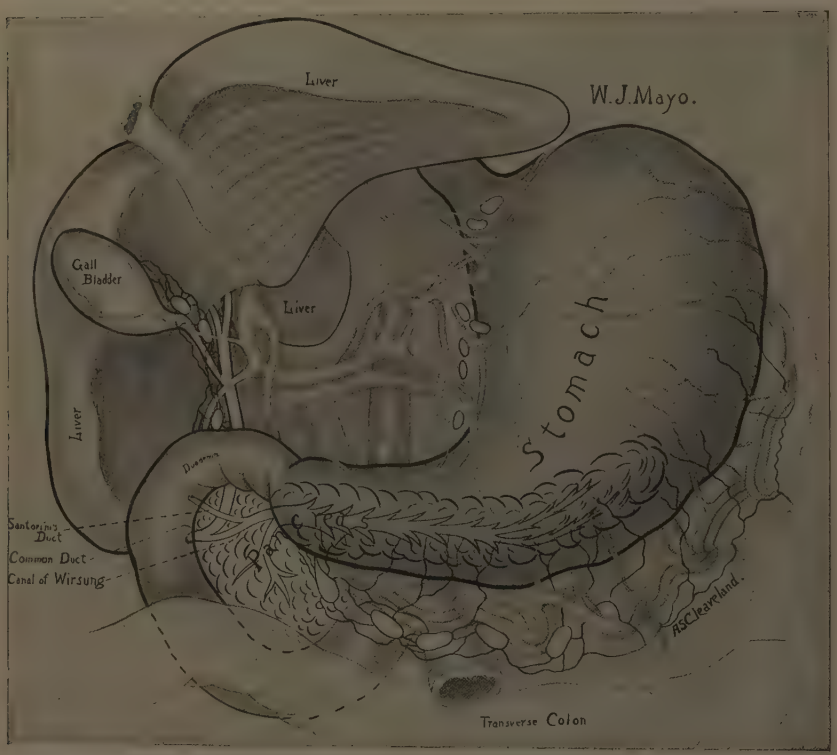


FIG. 508.—SHOWING THE RELATIONS OF THE LIVER, GALL-BLADDER, AND BILE DUCT TO THE STOMACH, DUODENUM, AND PANCREAS.

During the fourth week of development a diverticulum, consisting of two buds or processes, pushes from the duodenum into the mesogastrium and forms the pancreas. These two pancreatic lobes to some extent retain their primitive form, having two openings into the duodenum, Wirsung's duct being the chief and Santorini's the lesser.[2]

The pancreas is originally completely surrounded by peritoneum. Later it loses its posterior layer, thereby fixing the duodenum. When fat necrosis takes place from pancreatic leakage, it follows the prim-

itive lines; *i. e.*, it spreads into the peritoneal cavity as well as behind it.[3]

The gall-bladder has a capacity of about one ounce and is from two and a half to four inches in length. It is capable of considerable distention, and is covered in the larger part of its extent by peritoneum, the attachment to the liver occupying from one-eighth to one-third of its circumference. Rarely it has a complete mesentery. The gall-bladder is united to the common duct by the cystic canal, an inch

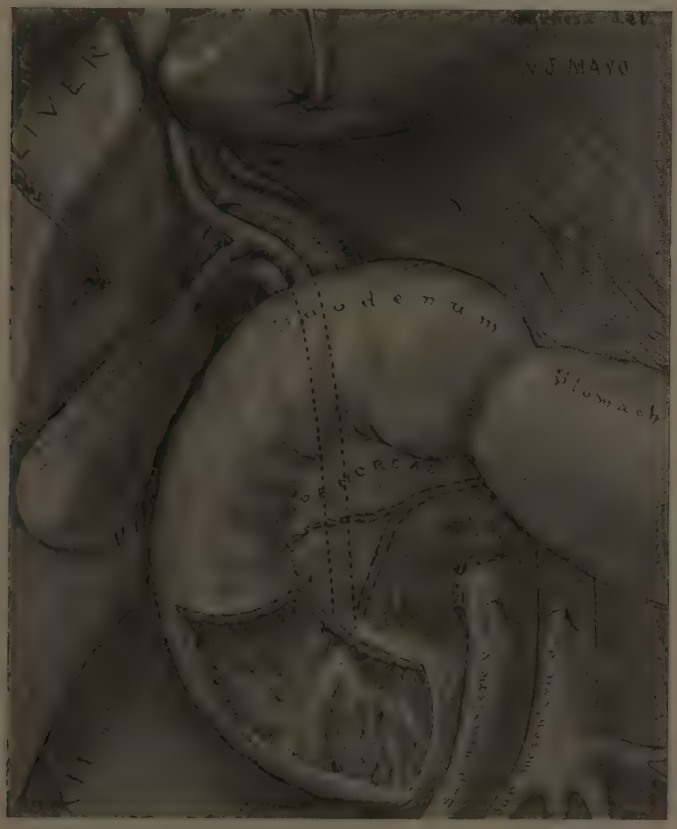


Fig. 509.—Relations of the Gall-bladder and Bile-duct.

to an inch and a half in length, and about one-eighth of an inch in diameter. In all hollow organs having storage function the outlet is elevated above the lowest point to prevent the pressure of the contents falling upon the sphincter muscles. The exit of the cystic duct conforms to the rule and is not at the bottom of the bladder, but is slightly higher on the inner side, giving rise to a little pocket at the bottom of the gall-bladder known as the pelvis or Hartmann's pouch.

The common duct is one-sixth of an inch in diameter and from three to three and one-half inches in length, and lies nearly longitudinal with the long axis of the body.

In the average case of common duct obstruction, if the dilated duct be opened close to the cystic duct, the first joint of the forefinger can be introduced through the hepatic duct, into the entrance of either primary division. For about one and a quarter inches the common duct lies exposed in the right inferior margin of the gastrohepatic omentum, fairly close to the hepatic artery and the portal vein.

The first or supraduodenal portion is the point of election for the removal of stones from the common duct.[4] The duct is not sufficiently near the portal vein and hepatic artery to render these liable to harm during operations, if due care be observed; the danger from this has been greatly exaggerated.

The second or retroduodenal portion of the common duct, one inch in length, lies behind the duodenum, while its internal or third portion is in close proximity to the head of the pancreas and between this organ and the second portion of the duodenum.

The common duct joins with the pancreatic duct of Wirsung about three-fourths of an inch from its termination. The terminal portion as it passes through the intestinal wall is somewhat dilated and this dilation is called the ampulla of Vater. The entrance of the combined common bile, and pancreatic ducts into the duodenum is at the papilla on the left posterior wall of the gut, about four inches below the pylorus. The papilla is situated at the upper extremity of a longitudinal fold of mucous membrane, and is nearly covered by the first normal transverse mucous fold (valvula connivens). This appearance is rather striking and facilitates identification. During life the escape of pancreatic and biliary secretions affords an even more ready means of localization.

The duct of Wirsung, in 83 per cent. of the cases, carries all of the pancreatic secretions.[5] The duct of Santorini is always present. In 12 per cent. of the cases it is the main duct, and in 54 per cent. is capable of acting as a substitute for the duct of Wirsung upon closure of the latter. This fact is important when common duct stones and infections of the pancreas are present.

The gall-bladder receives its blood-supply through the cystic artery which usually comes off from the hepatic paries, some little distance posterior to the cystic duct and reaches the gall-bladder just above the neck. The cystic artery occasionally arises from the superior pancreatoduodenal artery, and if so, may run along the common duct and may readily be injured in operations upon the latter channel It bleeds so sharply if cut that it has been mistaken for the hepatic artery, but is of no great importance if caught and ligated.

A short transverse vein is frequently found on the free surface of the common duct; when injured this vein has occasionally been mistaken for the portal vein, on account of the profuse venous hemorrhage.

The lymphatic glands are not numerous The gall-bladder itself contains no lymph nodes and but few lymphatic channels. One gland

is to be found at the junction of the cystic with the common duct, and a few scattered glands lie along the common and hepatic ducts and in the gastrohepatic omentum.[6]

As shown by Lennander,[7] the visceral peritoneum is poorly supplied with sensory nerves. Jonas, however, has demonstrated that branches of the eleventh and twelfth dorsal and first lumbar nerves pass forward onto the diaphragm, and that their terminal filaments reach the common and cystic ducts and the neck of the gall-bladder, so that this vicinity is sensitive to touch, and when irritated gives rise to the characteristic diaphragmatic spasm of gall-stone colic, and a "grunting" respiration on manipulation even under profound anesthesia.

At birth the liver is relatively very large, but the change in blood supply diminishes the rapidity of its growth, so that it soon loses its predominance. The hepatic function with which we are concerned is that of the production of bile, which varies in quantity from 20 to 30 ounces a day. This is composed of fluids, pigments, and other matter, largely the result of the destruction of the worn-out red blood corpuscles. It is strongly alkaline in reaction, and is active in stimulating the secretion of pancreatic ferments, especially is it valuable for its emulsifying mechanical effects in aiding digestion. The fluid parts of the bile are re-absorbed in the cecum, while the pigments and waste solids act as a stimulant to the large intestine, and are passed off with the stool.

It is supposed that the gall-bladder acts as a storehouse and that here bile is stored in the periods between meals. When one considers that the twenty-four hour output of bile is from 20 to 30 ounces or more, the single ounce held in the gall-bladder is trifling. Further, it has not been shown that the gall-bladder forcibly contracts when it is full. Murphy[8] believes that the gall-bladder acts like the second bulb of a syringe, to produce a steady flow, instead of a jet-like discharge, from the common duct into the duodenum. Certain it is that its function, as far as known, is unimportant, and there is evidence to show that it is obsolescent and has about the same status as the appendix and the wisdom teeth.

It has been thought that bile is sterile. This is untrue, if a sufficient quantity is examined. Adami[9] and Ford have shown that leukocytes pass out on the free surface of the duodenum and upper jejunum, picking up particles of fat and bacteria, especially bacilli, and that these are destroyed in the lymphatics. The portal radicles, however, are continuously absorbing bacteria, which are carried to the liver and annihilated or attenuated and excreted with the bile. It is this attenuated infection of the gall-bladder and interference with drainage which probably underlies gall-stone disease (Lartigau).[10]

ANOMALIES AND MALFORMATIONS OF THE BILE TRACT.

Anomalies of the gall-bladder and bile passages are not infrequent.[11] In examining the reported cases, however, one is convinced that a con-

siderable proportion are the result of disease, rather than true congenital malformations. Transposition of the viscera with the gall-bladder on the left side, is of infrequent occurrence, but cases of this anomaly have been reported in which gall-stones formed, necessitating operation.[12] [13] A number of cases are reported in which a double gall-bladder existed, each with a separate cystic duct: also examples of gall-bladders situated within the liver substance, and a third variety, in which the gall-bladder was directly connected with the hepatic ducts in the liver itself, there being a congenital absence of the cystic duct. In some specimens there is no main hepatic duct, the right and left primary divisions extending down to the cystic and common duct; or the right primary division is joined by the cystic duct, and the left primary division extends down nearly to the duodenum before uniting with its fellow.

Congenital absence of the common duct has been noted, all the ducts having separate openings into the duodenum. The common duct in a small percentage of cases fails to unite with the pancreatic duct, and each has a separate opening. Congenital obliterations of the common and hepatic ducts have been reported. Some 60 or 70 cases have been collected by Thomson,[14] in 1 of which Summers[15] performed the operation of choledocho-enterostomy. Choledochostomy has been performed a number of times for the relief of this condition.

SURGICAL SIGNIFICANCE OF JAUNDICE.

Jaundice is so important a sign in diseases of the biliary passages that a careful study of its characteristics is essential to a proper differential diagnosis.

Surgically speaking, jaundice is always obstructive, and means that at some point in the bile ducts there is an interference with drainage, either from within the lumen of the duct, *e. g.*, an infection which causes swelling of the mucous membrane and reduction of its carrying capacity, or a mechanical obstruction from foreign bodies, such as calculi, tumors, and even lumbricoid worms which have entered through the duodenal orifice.[16] In two cases we have seen common duct obstruction caused by the pressure of enlarged lymph glands. Interference with duct drainage is also brought about by pressure from without, due to new growths, local peritonitis, adhesions, and plastic exudates, such as occur about chronic perforations, or ulcers of the duodenum and pyloric end of the stomach.

The most important point to be considered is that jaundice of itself has nothing to do with gall-stones in the gall-bladder. So long as the calculi lie within their natural habitat, jaundice is not to be expected; and if it occurs, it means either that an infection has descended from the gall-bladder through the cystic duct, and involves the common and hepatic ducts, or that the calculi have moved down into the great bile ducts.

Courvoisier[17] long ago pointed out that tumor in the region of the gall-bladder with jaundice usually means malignant disease; he demon-

strated that in 86 per cent. of cases of stone in the common duct, the gall-bladder is contracted.

The more common sources of obstructive jaundice are, first, inflammation of the gall-bladder with or without stones, in which the infection extends down the ducts until the common and hepatic ducts are involved. The history of previous colics without jaundice, and the fact that the jaundice disappears, as a rule, within a very few days, without marked loss of flesh or general disturbance, will lead to the differentiation.

Second, penetration of the infection through the gall-bladder or the cystic duct to the peritoneum may give rise to a local peritonitis and a temporary jaundice. A history of gall-stone disease, with the local pain and tenderness due to the regional peritonitis, and the temporary character of the symptoms, indicate the cause.

Stones in the cystic duct may cause great thickening and pressure on the common duct, giving rise to jaundice.

Stones in the common duct in the large majority of cases, give rise to jaundice at some time in their history, although in nearly 30 per cent. of the cases there may be no jaundice, and few symptoms at the time the patient is examined. A present or past history of gall-stone disease, with recurring chills, fever and sweating forming the syndrome described by Charcot,[15] is to be looked for. The jaundice is intermittent, and if severe is of a dark, dirty, yellowish color, with a dry, harsh skin from the accompanying infection and is attended by colicky distress; there is nearly always a definite loss of body weight.

Carcinoma of the gall-bladder producing jaundice gives rise to a painless tumor which comes on slowly before the jaundice. The color is a lemon yellow, and does not materialy change day by day except for the worse. It will usually be found on inquiry that at a period of months or years before the development of the nodular mass gall-stone disease was present.

New growths within the common or hepatic ducts are not necessarily accompanied by a previous history of gall-stones. The jaundice is usually of a dark, greenish-yellow hue, is painless and progressive, and no tumor is to be felt.

Chronic pancreatitis as a cause of jaundice usually has a history of gall-stone and there are moderate remissions in the jaundice itself, but not to the extent seen in common duct stones. While there is considerable loss of weight, there is not the progressive emaciation of malignant disease.

The jaundice of hypertrophic cirrhosis of the liver (Hanot) is differentiated by the lack of pain and the great size of the involved organ, while the jaundice of atrophic cirrhosis is usually preceded by an alcoholic history and an enlarged spleen is often present.

Catarrhal jaundice has nothing in its clinical course to suggest a surgical lesion, neither has the so-called hematogenous jaundice, which is due to the rapid destruction of red blood-corpuscles from toxic or chemical poisons.

INJURIES OF THE GALL-BLADDER AND BILE PASSAGES.

The normal gall-bladder and bile-duct are seldom injured by external force. Desrosiers,[19] in 1894, was able to collect but 25 reported cases, and in some of these there was pre-existing disease.

When we consider that the normal gall-bladder, dried and distended with air, will stand one hundred pounds pressure before breaking, one can well believe that indirect force sufficient to produce rupture can occur only under very peculiar circumstances. We have twice seen subcutaneous rupture, both in young children, and both in exactly the same way, the child slipping from a load of hay between the wheels and the entire weight of the load on a narrow wagon-tire was brought directly upon the margin of the costal arch. A small number of cases have been reported in which direct injury to these structures by stab and bullet wounds has occurred. In injury of the gall-bladder or ducts, jaundice will be present in a large percentage of cases. Desrosiers found it to occur in 65 per cent., while Meyer found that only 4.75 per cent. of cases of ruptured liver were attended by jaundice. In those who survive the injury twenty-four hours this percentage increases.

The jaundice from rupture of the gall-bladder may be less profound than when it results from laceration of the main bile ducts, and bile will still appear in the stool. There is also a marked tendency to develop a localization of the trouble, a condition not met with after rupture of the main bile ducts.

The behavior of the bile in the peritoneal cavity depends, to a very large extent, upon whether there is pre-existing disease or not. Normal bile is but slightly infectious. It may be tolerated for a considerable length of time, but in the presence of infections, such as in gall-stone disease, a fatal peritonitis is usually rapidly induced.

Ransohoff [20] calls attention to the fact that free bile in the peritoneal cavity gives rise to a localized jaundice of the umbilicus, a most valuable sign.

Surgical treatment should be immediate abdominal section, removal of the injured gall-bladder, and repair of the lacerated ducts with catgut sutures. A few cases are on record in which repeated aspirations of a biliary ascites following rupture in the bile tract has enabled nature spontaneously to close the injured part, but no reliance should be placed upon such a remote possibility.

Encapsulated accumulations, which have resulted secondarily to injuries, should be treated by drainage, without too extensive search for the point of perforation.

GALL-STONE DISEASE.

If gall-stones can be said to have a normal habitat, it is in the gall-bladder. Cases have been reported in which stones have undoubtedly formed in the common, and more especially in the hepatic ducts, without any involvement of the gall-bladder. We must, however, agree with Beers[21] that a stone from the gall-bladder which has become

lodged in the common duct is, with few exceptions, the cause of the accumulation of duct stones, of which it forms the apex.

Gall-stones occur three times as often in women as men. In eighteen hundred operations in our hands, 76 per cent. were in women and 24 per cent. were in men. It is hard to account for this sex disproportion.

As bacterial infection is one of the main factors in the production of gall-stones, it is thought by some authorities that constipation, which is more common in women, may play an important part in loading upon the liver an unusual number of bacteria of the colon group. The liver of man is one-thirty-sixth of the body weight; the liver of woman, one-fortieth.[22] It is possible that there is an equal disproportion in function; the liver of man being relatively more active, because larger.

It must be remembered, too, that the liver of the pregnant female must be able to care for mother and child, which throws an unusual amount of work upon that organ, and the number of cases in which the first symptoms of gall-stone disease were associated with pregnancy, either during, or soon afterward, is noticeable. Naunyn states that 90 per cent. of women with gall-stones have borne children.

Nearly 50 per cent. of all the cases are people above forty years of age. In both sexes, especially the male, gall-stone disease is rare under twenty-five years of age, but it has been reported in children, and even in new born infants.

There are three important factors in the production of gall-stones: The first, pointed out by Naunyn, is the remarkable association of micro-organisms with the origin of calculi. Cholesterin, which is the most important single calculus constituent, is a direct result of the action of bacteria upon the mucous membrane, and lime salts, when present, have the same origin. The micro-organisms which are most active usually belong to the colon group, including the typhoid bacillus. A great many cases of gall-stone disease can be directly traced to typhoid fever. In Welch's laboratory the typhoid bacillus has been isolated in pure culture from the gall-bladder seven years after an attack of typhoid fever. In the nucleus of gall-stones clumps of bacteria are often found.

The second important factor is obstruction to free drainage. This is usually the result of swelling from an infection of the mucous membrane produced by bacteria.

The third factor is the so-called lithogenous catarrh, or gall-stone diathesis, about which we know but little.

As to how the bacteria reach the gall-bladder there has been considerable difference of opinion. Bond has shown that there are reverse mucous currents in the intestines, and that indigo-carmine particles have been carried mechanically from the anus to the gall-bladder. It has also been shown that the bacillus prodigiosus, two hours after being placed within the anus of a rabbit, can be found in the animal's mouth. These facts lead one to believe that the gall-bladder infection is an ascending one from the duodenum. On the contrary, the duodenum

in the vicinity of the common duct is usually sterile, and the washing effects of the bile have been shown to be sufficient to keep the healthy duct clear of micro-organisms.

Experimentally, gall-stones have been difficult of production; the infection produced being, as a rule, of too virulent a character.

When we further consider that a peculiar attenuation of the bacteria is necessary for gall-stone formation, we must agree with Lartigau[23] that it is altogether probable that it is bacteria carried through the liver by means of the portal circulation which furnish the infected bile responsible for gall-stone production, the action of the liver cells being to destroy or attenuate the virulence of the micro-organisms.

Gall-stones may be single, but, as a rule, are multiple, and as many as eleven thousand have been reported.

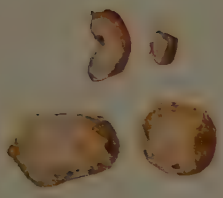
About 70 to 80 per cent. of the substance of the stones is cholesterin; the rest is composed of bile pigments and lime salts. These proportions are, however, quite variable. The calculi vary in size from a grain of sand to one reported by Robson[24] weighing nearly 3½ ounces—as large as a goose egg. Gall-stones are usually all formed at one time, although we have seen a few cases in which there were several crops of stones, as shown by the entire difference in color, size, shape, and proportion of the chemical constituents. The time of stone formation varies from a few days to a few weeks. The infected and obstructed gall-bladder becomes filled with a gelatinous material, and in this particles of deposit may be seen which act as centers of concentration. Stage by stage the process can be traced until the stones are complete.

Symptoms of Gall-stone Disease.—The symptoms of gall-stone disease depend upon their location in the biliary tract, the virulence of the accompanying infection, and the amount of obstruction.

The history is often the most valuable single means of diagnosis. It is essential that it should be complete, and that the evidence be carefully sifted and weighed. A patient may complain of chronic dyspepsia, and beyond that, only a possible tenderness on deep pressure over the gall-bladder area during forced expiration may be found. An early history of typical attacks of colic, possibly almost forgotten by the patient, will at once give a clue to the origin of the symptoms. Careful investigation into the history, with a comparatively small amount of external evidence, will many times enable the observer not only to diagnose gall-stone disease, but also accurately to determine their location.

Simple Gall-stone Disease.—Gall-stones in the gall-bladder, accompanied by a mild and intermittent infection, give rise to sudden colics. These colics are usually in the epigastric region, a mid-line pain, radiating to both sides, through to the back, and upward rather than downward. The pain begins suddenly, without regard to diet, exercise, or time of day, quickly reaches its maximum intensity, and lasts from a few moments to six or eight hours. The cessation of pain is as abrupt as its origin, and the feeling of relief is accompanied by vomiting or by a sensation of movement of gas; excepting for the effects due to the

PLATE X.



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GALL-STONES (Moynihan).

1, Almost free cholesterin; 2, cholesterin and bilirubin-calcium; 3, a stone removed from the ampulla of Vater; 4, a stone removed from the common duct; 5, a stone removed from the cystic duct.

suffering, the patient at once regains normal well-being. There is no elevation of temperature and the pulse beat is not increased.

The cause of the pain lies in a sudden temporary obstruction at the neck of the gall-bladder, either as the result of a lodgement of the stone or a swelling produced by infection. The gall-bladder rapidly becomes filled with a serous fluid, producing a spasm of its muscular structure. When this muscular contraction relaxes and permits the escape of the bladder contents, the attack is over. The reason why there is no quickening of the pulse rate, or elevation of temperature, lies in the fact that the gall-bladder has few lymphatic channels and no lymph glands, and, therefore, cannot absorb septic material with sufficient rapidity to produce bodily disturbance, and the gall-bladder is so distensible an organ that its elasticity does not permit of a great amount of tension.

Special attention should be called to the fact that there is no jaundice, and that the pain is a mid-line pain, which is often called "gastralgia." In this stage the attacks are intermittent and at times disappear for years without any intervening symptoms. It is in cases of this description that various forms of medication have given rise to erroneous belief as to their curative properties, the normal intermission being credited to the treatment pursued.

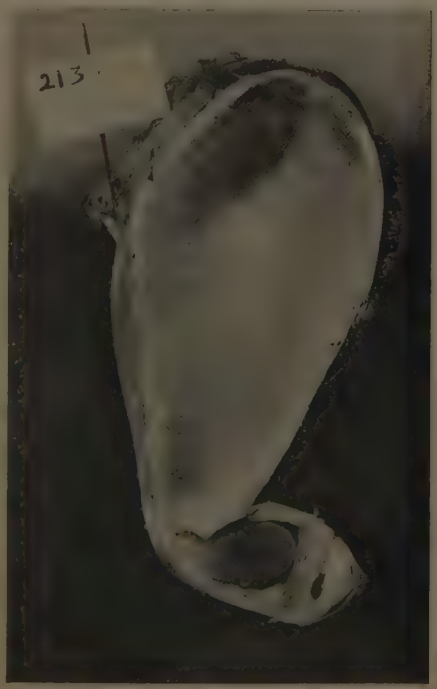

FIG. 510.—GALL-BLADDER WITH STONE IN PELVIS.

Operations for simple gall-stone disease are exceedingly safe. The operation of choice is a cholecystostomy, which has but a small primary mortality, certainly not exceeding one-third of 1 per cent. from all causes, and the percentage of cures is very high, at least 95 per cent. Cholecystectomy can also be performed, and by some is considered the preferable operation, but it has about one-third of 1 per cent. higher mortality.

Complications of Gall-stone Disease.—Gall-stones Impacted in the Pelvis of the Gall-bladder.—The attack usually begins in the same manner as in the simple variety just referred to, but the pain, which in former colics suddenly ceased at the expiration of a few hours, fails to do so in this particular attack, and is accompanied and followed by local tenderness and rigidity of the upper right rectus muscle. The

pain gradually abates, but the tenderness lasts several days, possibly weeks, and there may be a well-marked tumor formed by the distended gall-bladder.

The most common result is the so-called "cystic gall-bladder," in which the organ is filled with a clear, mucoid fluid without any evidence of bile. At other times, the material dammed up in the gall-bladder undergoes further infection and develops an empyema. The temperature at the height of the attack may rise to 101° or 101½° F., but not often higher, even though the gall-bladder be filled with infective pus. The pulse will also be but moderately quickened. The reason for the lack of septic symptoms lies in the fact that although the stone is obstructing the pelvis of the gall-bladder preventing the exit of material,

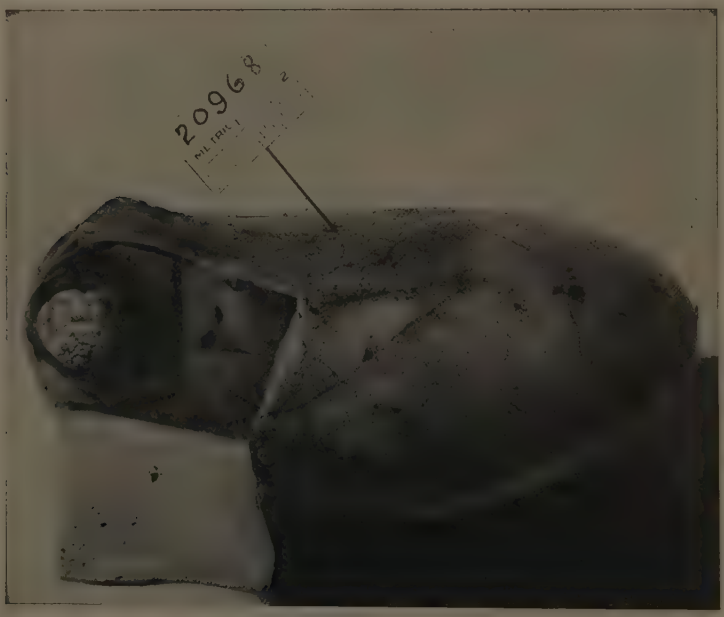

FIG. 511.—STONE EMBEDDED IN NECK OF GALL-BLADDER.

the only lymphatic gland which is capable of receiving the infection lies beyond the point of obstruction, and the gall-bladder is distensible, so that the tension is not great. In the average case the slight elevation of temperature speedily subsides, and the tumor in the course of a few days or weeks becomes much less noticeable, due to the slow absorption of the contents of the gall-bladder. Typical colics may not reappear, the stone becoming firmly fixed in the contracted gall-bladder, and the patient develops chronic dyspepsia, which defies medical treatment.

In other cases, the pressure gradually forces the stone into the cystic duct and from there down into the common duct, introducing a new train of symptoms.

When distended by infected material, the gall-bladder often becomes adherent to the duodenum, transverse colon, or stomach; under these conditions, a fistula may form and permit spontaneous evacuation of the contents of the gall-bladder into the gastro-intestinal canal. In rare instances the perforation of the gall-bladder into the free peritoneal cavity occurs, giving rise to general septic peritonitis. Typhoid perforations, due to localized gangrene, have been reported by Kiliani[25] and Erdmann. Usually the point of perforation is more or less protected and an encapsulated abscess forms. This abscess may slowly work to the surface of the body and empty itself; it may gravitate downward and spontaneously discharge into any of the hollow viscera; it may pass upward, forming a subdiaphragmatic abscess; or even perforate into the pleural cavity, and possibly, by means of adhesions, evacuate itself through a bronchus. The rule is that all of the stones do not escape through a spontaneous fistula, some remaining to cause further trouble.

Fig. 512.—Gall-bladder with Stone in Cystic Duct.

The indications are for cholecystectomy (removal of the gall-bladder and the stones), but on account of general local conditions cholecystostomy may be the preferable operation. If intestinal fistulæ exist they should be carefully closed by suture.

Stones in the Cystic Duct.—The rule is that stones in the cystic duct do not cause complete obstruction, and the gall-bladder usually contains more or less bile.

In the majority of cases the symptoms are not acute. There will be repeated attacks of colic, as pain accompanies movement of the stone in the duct; there is local tenderness and a gradual tendency of the stone to become forced by the muscular gall-bladder into the common duct.

Impacted stones in the cystic duct give rise to cystic gall-bladder or to empyema. These may spontaneously perforate, usually into the gastro-intestinal canal, and are particularly prone to fistulæ. Perforation into the stomach just above the pylorus is not uncommon and gives rise to acute pyloric obstruction.

There are three somewhat rare varieties of stone in the cystic duct which develop certain marked symptoms:

(*a*) Partial obstruction with deficient drainage *plus* rapid growth of bacteria frequently belonging to the colon group. The infected bile is discharged intermittently. When it attacks the bile ducts, it causes cholangeitis, with chills, fever, and sweating; when it attacks the pancreatic duct, it causes acute pancreatitis and fat necrosis. In the most severe cases the gall-bladder becomes distended, thin-walled, and the bile has a strong fecal odor.

(*b*) A stone impacted in the cystic duct with a contracted, thick-walled gall-bladder, containing a thin, mucopurulent, infectious fluid. At irregular intervals the patient will be suddenly seized with chills, sweating, and very high temperature, from 105° to 107° F. The symptoms rapidly subside, and are not accompanied by jaundice. There is usually considerable loss of weight with constant digestive distress. These peculiar symptoms ensue because the stone lies in a non-distensible duct, with lymphatic glands on each side capable of active absorption of the infected material, which is under much tension.

(*c*) A stone impacted in the cystic duct with a contracted gall-bladder may produce the most marked gastric symptoms, especially vomiting, indicating gastric or duodenal ulcer. The vomitus usually contains bile. There is emaciation which may be extreme.

For the relief of stone in the cystic duct, other things being equal, the indicated operation is removal of the stones by cholecystectomy. If the gall-bladder be simply drained after removal of cystic duct stone a stricture may result, leading to intermittent colics, as the contained mucous secretions are forced down through the obstructed ducts, or cause a mucous fistula to the surface from complete obstruction. If the gall-bladder contains bile, and the stone can be removed without permanent injury to the ducts, cholecystostomy may suffice. Should there be evidence of infection of the deep ducts of the liver at the time of the operation cholecystostomy is the safer operation, because it drains the liver ducts and relieves hepatic tension.

Stones in the Common Duct.—Gall-stones in the common duct, in the majority of cases, give rise to jaundice. The colicky pains may not be severe, but are frequent. The jaundice changes day by day in the early stages, but eventually, especially in the case of single stones, may become completely obstructive. These cases are prone to attacks of cholangeitis, causing chills, fever, and sweating, with high temperature, 103° to 107° F., but all of these symptoms may subside and for a time there may be comparatively few symptoms. The stones may remain in the common duct or in a diverticulum for years without marked disturbance, but, as a rule, there is loss of flesh and dyspepsia. About 30 per cent. of patients are in the quiescent stage and without jaundice when they come under observation.

The *symptoms* in common duct disease depend entirely upon infection and obstruction. These are influenced by the location of the stone. If the stone is obstructing the ampulla, jaundice will be marked and pancreatic involvement may present itself as a complication. The extent of the pancreatic complication depends upon the virulence of

the infection, and, as shown by Opie, on the ability of the pancreas to drain itself through the accessory pancreatic duct of Santorini. A movable stone, which is just too large to pass through the papilla of the duct (described by Christian Fenger[26] as a "ball valve stone"), gives rise to very marked symptoms of intermittent jaundice and recurring attacks of cholangeitis, with high temperature, 103° to 107° F. The stone moves about freely in the duct with consequent constant irritation and infection and occasionally may block the outlet.

Stones in the common duct frequently discharge after slow dilation of the papilla. Temporary attacks of jaundice with pain and local tenderness, suddenly relieved, usually indicate that the stone has passed into the duodenum, and that it may be recovered from the stool.

In the common duct stones may ulcerate through into the gastro-intestinal tract, usually the duodenum. Most marked symptoms of obstructive jaundice and local peritonitis, with elevation of temperature were present in four patients on whom we considered operation inadvisable; but after the lapse of from six to eight weeks in each case, a stone passed through the intestinal tract, and prompt recovery ensued. All the stones, however, do not usually escape by the fistulous passage. We have had an opportunity in a number of instances, during the removal of retained stones, to follow the course of those that made spontaneous exit.

Stones may reform in the common duct after removal. We have had this happen three times after a cholecystectomy had taken away the possibility of the usual site of formation. We have never known recurrence of stones in the common duct after cholecystectomy, except under one or more of the following conditions: the stones removed had originated in the gall-bladder; they had left, as a legacy, an infected and thickened common duct; they had given rise to chronic pancreatitis, which in turn interfered with efficient biliary drainage.

Stones in the common duct should be removed by choledochotomy and temporary biliary drainage to the surface be established.

Hepatic duct stones may be classed with common duct stones, as they are practically always accompanied by such, and are secondary to them. In the large majority of cases stones in the hepatic ducts have had their origin in the gall-bladder. The stones have passed from the gall-bladder to the common duct, thence gaining access to the dilated hepatic duct. Under these circumstances, fresh calculi may be formed in the hepatic ducts themselves. Such are usually little, disc-shaped stones, of black or dark brown color, without facets. Occasionally, however, stones may form in a considerable length of duct and be pressed so closely together as to produce facets. It is difficult, and often impossible, at operation, to remove all of the hepatic duct stones, and preparation must be made for their escape either by the freest possible drainage from the common duct to the surface of the body or by dilation of the papilla. We have removed several hundred stones from the hepatic ducts, and then had a continuous discharge of calculi from a common duct fistula for a number of days.

NON-CALCULOUS CHOLECYSTITIS.

Inflammation of the gall-bladder without stones is not at all uncommon, and it is quite possible that in many instances such a condition has long preceded the formation of calculi.

Three varieties can be distinguished: *First*, Acute phlegmonous cholecystitis, in which there is virulent infection with thrombosis of the vessels. In this the entire gall-bladder rarely, more frequently the mucous membrane, becomes gangrenous. Perforation sometimes take place into the free peritoneal cavity, giving rise to general septic peritonitis. The perforation may occur gradually, the extravasated material becoming encapsulated, forming an abscess with secondary fistula, and the discharge of the contents into the gastro-intestinal tract or to the surface. A large variety of bacteria are found in these cases. Most commonly they are from the colon group, and in nearly all cases streptococci are present, usually with other micro-organisms. Rarely, acute phlegmonous cholecystitis occurs during typhoid.

Cholecystectomy is the indicated surgical treatment (see p. 1019).

Second, subacute cholecystitis, in which the inflammation does not seriously affect the wall of the gall-bladder. There is a tendency for this organ to become greatly distended. Its walls are not much thickened and the contents consist of bile and mucus, usually thin in character and frequently foul-smelling with marked fecal odor. These cases sometimes give rise to very marked symptoms from the escape of the infected fluids into the deep ducts, shown by chills, sudden, irregular high temperatures, and a moderate amount of jaundice. Subacute cholecystitis is particularly apt to be the originating focus for a fatal septic cholangeitis, or for acute pancreatitis and fat necrosis. Upon examination the gall-bladder will be found much enlarged, and non-compressible, it being impossible to empty it of its contents by pressure. There will be a moderate amount of adhesions about the fundus, and as no stones can be felt in its cavity some doubt as to the nature of the malady will be experienced, until, upon opening the gall-bladder, its contents at once explain the nature of the pathologic condition.

If, at the time of the operation, the hepatic ducts are wholly free from involvement, cholecystectomy is the operation of choice, but if there is any evidence whatever of infection of the liver ducts in an acute or subacute stage, prolonged drainage of the bile to the surface by cholecystostomy is essential because the condition of the hepatic ducts overshadows the cholecystitis.

In cholecystostomy for this trouble suture the gall-bladder to the aponeurosis external to the muscle, just beneath the skin, for the following reasons:

(*a*) If, as is common, relapse occurs, this superficial attachment permits of spontaneous re-establishment of the fistula.

(*b*) In cholecystostomy the gall-bladder is usually united to the peritoneum, and if relapse takes place a second operation becomes necessary.

(c) If the gall-bladder is attached to the skin a permanent muco-cutaneous fistula is liable to result, requiring a plastic operation for its closure.

Third, chronic cholecystitis. The gall-bladder is filled with thick muco-bile of a dark, viscid character, and often there is a considerable amount of adhesions, binding the peritoneal surface to the surrounding viscera. The lymphatic glands about the neck of the gall-bladder and along the common duct are noticeably enlarged. On opening the gall-bladder and removing its contents, little pigmented areas of a yellowish color are found scattered over its mucous surface, giving it a speckled appearance. These are quite characteristic, and are due to erosion of the superficial epithelium, with deposit of bile pigments at various points.

Before making a diagnosis of non-calculous chronic cholecystitis, one should examine the appendix, the right kidney, and the pyloric end of the stomach and duodenum to see that there is no error, because, as a rule, the diagnosis cannot be fully established until the gall-bladder is opened, and if the conditions above noted do not exist it is probable that the clinical symptoms do not have their origin in a cholecystitis. General exploration cannot be so safely carried out after opening the gall-bladder as before doing so.

If there is no evidence of any involvement of the hepatic ducts cholecystectomy is the indicated operation, but if there is the slightest doubt cholecystostomy with prolonged bile drainage is an equally effective, although slower, method of cure.

COMPLICATIONS AND SECONDARY CONDITIONS RESULTING FROM GALL-STONE DISEASE.

Acute perforation of the gall-bladder into the free peritoneal cavity is marked by all the symptoms of visceral perforation, whether it be of the duodenum, stomach, pancreas, or appendix. The patient usually gives a history of gall-stone disease, and previous to the sudden symptoms, colic or distress occasioned by obstruction and distention of the gall-bladder has been present. General peritonitis is rapidly set up from the infected fluids escaping through the perforation. The tendency of the material which escapes from the gall-bladder is to gravitate downward into the appendical region, and at once gives rise to the idea that the case is one of perforated appendicitis. A careful history, however, and the location of the early symptoms, such as pain and muscular rigidity, in the region of the gall-bladder, will enable us to make a differentiation.

The treatment should be immediate abdominal section for the removal of the gall-bladder and free drainage.

Fistulous communications between the gall-bladder or the bile ducts and the gastro-intestinal tract, usually close spontaneously, but occasionally they give rise to marked symptoms of obstruction, especially when these exist in the vicinity of the pylorus.

Fistulæ which lead to the surface of the body are not at all infrequent, and at some point between the skin and the involved gall-bladder or duct calculi will usually be found.

The treatment of intestinal fistula should be division and closure of the intestinal opening by purse-string suture of linen or silk. If the gall-bladder is the offending organ it should be removed, and drainage established by means of rolls of rubber tissue. Gauze drainage is very liable to be followed by secondary fistulæ.

When the vicinity of the pylorus is involved after cutting loose the fistula, plastic closure should be made in such way as not to narrow the lumen of the gastro-intestinal canal. In rare instances it will be necessary to do a gastro-jejunostomy to overcome the obstruction.

Adhesions and bands, limiting the function of the gall-bladder or interfering with drainage through the ducts, are occasionally found, and give rise to marked symptoms. Gall-stones may or may not be present. In nearly all cases of gall-bladder disease extensive adhesions are to be expected, and it is rather surprising that they so rarely give rise to symptoms.

The treatment should be abdominal section, with removal of the gall-bladder and the calculi, if present, and division of the bands. The omentum and transverse colon should be[27] transplanted upward, so that when new adhesions form they will not interfere with organs like the duodenum and stomach, the functions of which depend upon motility, but with structures which will not give rise to unpleasant symptoms.

Strictures of the ducts are usually the result of the prolonged lodgment of stones, contraction resulting after the stones have been passed spontaneously or removed surgically.

Such strictures or kinking usually occur in the cystic duct, and if cholecystostomy has previously been done a mucous fistula to the surface may be the result.

Strictures in the cystic duct should be treated by removal of the gall-bladder.

Strictures of the common duct are much more serious, but fortunately, are relatively rare. Treatment may be either by (*a*) plastic operation; (*b*) complete division at the strictured area and re-implantation into the duodenum; or (*c*) cholecystenterostomy.

Involvement of the pancreas in gall-stone disease is exceedingly common, and will be found discussed in the chapter on "Diseases of the Pancreas."

A study of the anatomic relations of the common duct and pancreatic ducts will elucidate the reasons for the pathologic conditions presented. It is probable that nearly 50 per cent. of acute infections of the pancreas have their origin in infection of the biliary tract, and 75 per cent. of the chronic involvements of the pancreas have the same etiology. So true is this that stones in the common duct are, in the very large majority of cases, associated with chronic thickening of the head of the pancreas.

TUMORS.

Benign tumors of the gall-bladder are exceedingly rare; adenoma of the mucous membrane being the most frequent, showing itself by a distinct polypoid growth projecting into the lumen of the organ. In one case of our own, such a tumor acted as a ball-valve, causing intermittent obstruction. Robson reports a similar case. Almost the entire range of benign tumors are occasionally met with, but are so infrequent as to be merely surgical curiosities. Those interested will find an excellent resumé of the literature in Rolleston's "Diseases of the Liver, Gall-bladder, and Bile Ducts."

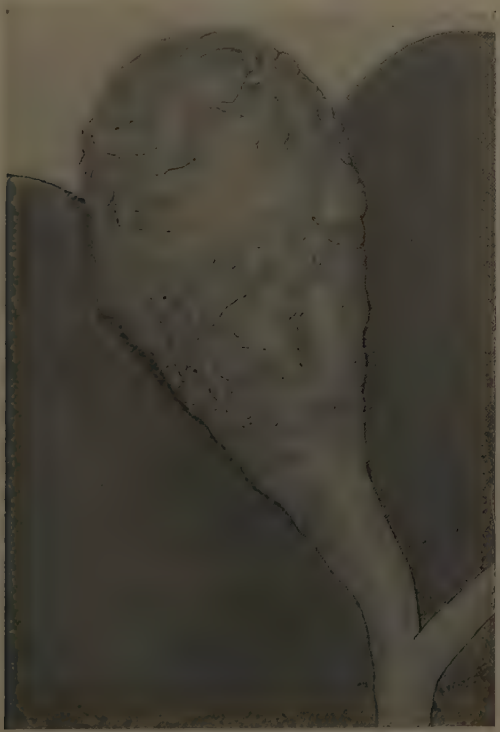

FIG. 513.—GROSS APPEARANCE IN A CASE OF CANCER OF GALL-BLADDER. (J. Garland Sherrill.)

Cancer of the Gall-bladder and Bile Ducts.—In eighteen hundred operations upon the gall-bladder and bile passages, we found malignant disease present in 4 per cent. In about 75 per cent. of these the gall-bladder was affected and in 25 per cent. the bile ducts. The rule is that the disease is too far advanced for radical extirpation when the patient comes under observation, but now that cholecystectomy has a widening field, it occasionally happens that in removing a thick-walled and functionless gall-bladder early cancer is accidentally removed. We have met with seven such instances. Three of them are

now well after more than two years, while none of the cases in which we were able to recognize that the disease was cancer at the time of the operation lived more than one year.

Cancer of the Gall-bladder.—Cancer of the gall-bladder, so far as our experience goes, does not exist in more than 4 or 5 per cent. of the cases that come to operation; although Schroeder says that no less than 15 per cent. of the patients with gall-stone disease eventually succumb to cancer, and Sherrill[29] puts the percentage at about 14. In at least 75 per cent. of the cases, the subjects are women, practically the same sex disproportion as is exhibited in gall-stone disease. Courvoisier[30] found that 74 out of 84 cases of malignant disease of the gall-bladder had gall-stones. Siegert[31] states that in 95 per cent. of all cases of primary cancer of the gall-bladder gall-stones are present, and adds this important fact that gall-stones are found in only 15 per cent. of secondary cancers of the liver. Beadle,[32] in the London Cancer Hospital, found that in primary cancer of the gall-bladder and liver gall-stones were present in all, and in twenty-six secondary liver cancers gall-stones were present in none. Musser[33] comes to the same conclusion in his excellent monograph on this subject.

The following indisputable facts attract attention.

First, gall-stones are almost always present in primary cancer of the gall-bladder, and not in secondary metastasis.

Second, the relative disproportion of malignant disease of the gall-bladder and gall-stone disease in men and women is practically identical.

Third, the pathologic lesions actually found are best explained on the irritation theory.

The diagnosis of primary cancer of the gall-bladder may be easy. In the history, evidence of active gall-stone disease at some time in the past can usually be elicited, but, as a rule, there is a long interval of comparative health before the development of the malignant disease.

A hard tumor, which has come on painlessly, can often be detected in the region of the gall-bladder. There is progressive loss of weight and later cachexia is developed. The tumor becomes more nodular as the liver is involved, and jaundice from involvement of the common and hepatic ducts is usually present in the later stages.

Naunyn says that at least one-half of the cases of jaundice diagnosticated as gall-stones are caused by or complicated with cancer. In our experience this is altogether too high a percentage. Jaundice, when it appears, is persistent and unchanging. Courvoisier demonstrated that 86 per cent. of cases of tumor, with jaundice, were due to malignant disease.

Not all hard tumefactions of the gall-bladder are cancers, however. Robson[34] details 1 case in which a hard, thick-walled gall-bladder, supposed to be malignant, was opened and drained. The patient eventually recovered and remained well. Abbe reports an almost identical case.

The site of the cancer in the gall-bladder is usually near the fundus. Sutton[35] finds general carcinomatous infiltrations of the gall-bladder,

forming a thick-walled tumor in the center of which is a cavity containing stones, to be the more common variety. Butlin[36] says that the carcinomatous ulcer is more frequently found. In other cases a tumor will be found projecting into the cystic cavity.

Surgical Indications.—Carcinoma confined to the gall-bladder should be promptly excised, and with it the associated border of the liver.

Jaundice, extensive involvement of the liver, peritoneal grafting, ascites, and deep lymphatic metastasis are contra-indications to radical operation.

Sarcoma of the Gall-bladder is exceedingly rare. Musser found but 3 reported cases. A small number have been collected since his classical monograph, in one of which operation was performed. The disease may be looked upon as a surgical curiosity and has no apparent etiologic relationship to gall-stones.

Cancer of the common bile duct is rare. Kelynach, in 4578 autopsies, found 8 cases of primary cancer of the gall-bladder, but 2 having origin in the duct. Musser collected 100 cases of carcinoma of the gall-bladder and 18 of the bile ducts. The site of the neoplasm in the common duct is either at the junction of the hepatic and cystic ducts, or near its duodenal termination. Of 18 collected cases 3 showed in the hepatic duct, 14 in the common duct, and of these latter, 9 were at or near the papilla. Rolleston, in 17 cases of cancer of the ducts, found 2 in the hepatic and 15 in the common duct, of which 10 were at or near the papilla.

While gall-stones can be conceded to be the most important etiologic factor in the causation of cancer of the gall-bladder, this is not true of the ducts.

First, the sexes are equally liable. Second, Edes, in 22 collected cases of cancer at or near the papilla of the common duct, found gall-stones in but 4, and in 3 of these the stones were found in the gall-bladder itself, not in the duct. The extensive experience of Robson, however, entitles his opinion to great weight. He believes that gall-stones are the most common cause of malignant neoplasms in the biliary passages, and that the reason the stones are not found is that they have passed out.

The histological variety of carcinoma of the ducts is the columnar cell type. The growth progresses by contiguity and involves the lymphatic glands late. The tumor is usually quite small, as a rule not larger than the end joint of the finger. It is of a very hard, almost stony consistency, and of a grayish-white color, and cuts like gristle.

Jaundice is an early symptom. As a rule, it is painless and not accompanied by septic manifestations in the ducts, although some cases have been reported in which ulceration led to duct infection, with chills, fever, and sweating. The distended gall-bladder can often be detected on palpation. In the early stages the jaundice may be intermittent. In the later stages, it is complete, with progressive emaciation. The course of the disease is rather slow, and a year or

more may elapse from the beginning of the disease as evidenced by jaundice before death occurs.

A considerable number of tumors of the ducts have been operated upon. Moynihan[37] presents an excellent resumé of the cases operated upon and the results.

The growth and the affected part of the duct should be excised, with re-implantation of the divided end of the duct into the duodenum at a new point, or in case of resection in continuity, end to end anastomosis by suture. Closure of the duct with cholecystenterostomy for permanent bile drainage has been advocated. For *palliation* the bile may be drained to the surface by means of cholecystostomy, or cholecystenterostomy may be performed.

OPERATIONS UPON THE GALL-BLADDER AND BILIARY DUCTS.

Surgical interference in gall-stone disease should be instituted, other things being equal, as soon as the evidence renders the diagnosis certain. Nearly every argument used for early operation in appendicitis applies to biliary calculi. The mortality of operations for the relief of simple gall-stone disease does not exceed one-third of 1 per cent.,

FIG. 514.—BALDWIN TABLE WITH LILIENTHAL GALL-BLADDER ELEVATOR.

and taking all conditions for which operations confined to the gall-bladder are necessary it does not average over 2 per cent. The safe time to operate is while the gall-stones are in their natural habitat, and before involvement of the deep ducts and the pancreas, or the development of malignant disease greatly endangers the patient's existence and increases the mortality.

In eighteen hundred operations which we have performed, no less than one patient in six had permitted the favorable time to go by before submitting to operation.

Involvement of the biliary ducts in gall-stone disease has the same significance as extension to the peritoneal cavity has in appendicitis.

Table, Instruments, Operative Material, etc.—Comparatively few special instruments are necessary beyond the ordinary working list.

First, as to the operating table. Some provision for elevating the lower chest in order to throw the intestines downward and thereby increase the abdominal aspect of the costal opening, as first recommended by Elliot.[38] is of advantage. This is ordinarily accomplished by the use of a sand-bag twenty-four inches in length and sixteen inches in circumference, which is placed across the ordinary operating

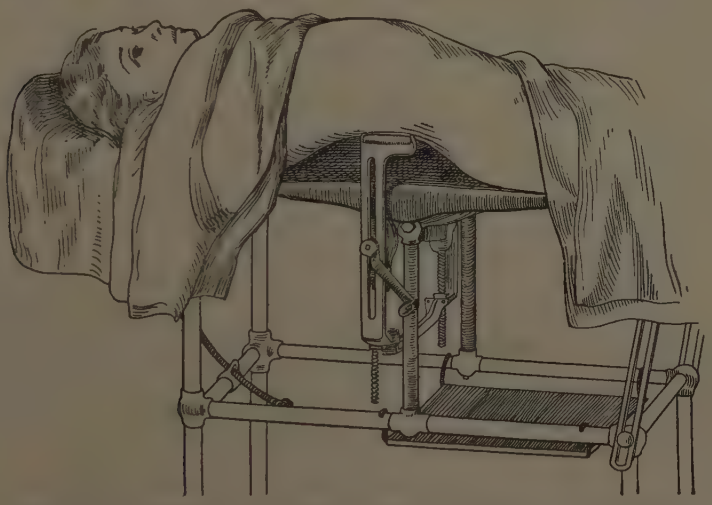

FIG. 515.—PATIENT IN J. W. ELLIOT'S POSITION ON THE LILIENTHAL BRIDGE.

table just beneath the short ribs. The objection to its use is that if placed prior to the giving of the anesthetic it renders the patient very uncomfortable, and if placed afterward it necessitates a readjusment of the protection about the field of operation. Also, it does not allow of easy change of position. For these reasons, many operating tables are made with a screw elevator which lifts up a narrow section of the table to the desired position and serves a very useful purpose. Another good table is one which has a break in it at the proper point, giving a double inclined plane when so desired.

The curved Carmalt artery clamps, six and one-fourth inches in length, are especially useful in these operations. They are too long to be readily lost in the abdominal cavity, as has happened with the short artery forceps, and their elasticity enables gentle grasping of the tissues without laceration, while the curve is about that of the under surface of the liver.

A medium ratchet retractor of the Simpson type is useful, and enables the operator to dispense with the hands of an assistant. For work about the deep ducts, the curved, smooth retractors of Deaver are valuable. As a matter of fact very little retraction is usually necessary, and this is best secured by the hand of an assistant, aided by a piece of gauze to prevent slipping.

The Ochsner aspirating trocar for removing the contents of the gall-bladder is a most valuable device for cleanly evacuating the contained fluids. The long needle forcep of Murphy, and the small, stout, catgut needle of the Dibrell-Ferguson pattern, are those we prefer for deep suturing. The best gall-bladder scoop is that of Robson. For special purposes the Finney scoop, which has a block-tin malleable shank is useful in removing stones from deep situations.

FIG. 516.—SCANLAN-MORRIS TABLE WITH ELEVATION BY ANGULATION.

For loosening up impacted stones, a long probe-pointed grooved director, bent and somewhat angulated half an inch from the tip, will sometimes be of considerable assistance.

A gall-stone forceps modified from the Blake pattern, so that it acts like a molar tooth extractor, should be at hand. The angle is such that if the tip of the forceps pass beyond the middle of the stone, it has a tendency to crowd the stone up into the grasp of the forceps and does not readily break it.

For draining the gall-bladder in cystostomy, we prefer a one-fourth inch rubber tube wrapped with four thicknesses of 5 per cent. iodoform gauze, and rolled about this, rubber tissue. On placing this in the gall-bladder, the walls can be tied sufficiently tight around the packing about the rubber tube to render it bile-tight, without interfering with the carrying capacity of the tube itself. The tube is held in position

by a purse-string suture of catgut which is passed through its gauze wrappings, holding a few days until the catgut dissolves.

For drainage outside the gall-bladder, the split rubber tube of Robson, made by splitting an ordinary rubber tube of the required size throughout its length and packing it with a strip of 5 per cent. iodoform gauze; or the ordinary "cigarette drain," composed of gauze

FIG. 517.—INSTRUMENTS FOR OPERATIONS ON GALL-BLADDER AND BILE-DUCT.

1, Scalpel with "firm grip" handle; 2, probe-pointed scissors curved on flat; 3, Finney's gall-stone scoop with malleable shank; 4, Robson's gall-stone scoop; 5, modified Blake gall-stone forcep; 6, probe-pointed grooved director, malleable shank; 7, Ochsner's aspirating trocar; 8, Kocher dissector with eye in end; 9, Kelly gauze packer; 10, malleable long probe; 11, Kelly needle holder; 12, Dibrell-Ferguson needle; 13, Murphy needle holder; 14, medium Simpson retractor; 15, Deaver's long retractor; 16, Deaver's short retractor; 17, Péan's forceps; 18, Carmalt forceps curved.

wrapped with rubber tissue, may be used with advantage. All gauze for drainage purposes should have a selvaged edge, so that threads may not be left behind through irregularity of cutting from the end of the gauze roll.

Narrow strips of folded gauze are also very useful for mopping out the gall-bladder.

For draining the common duct we prefer the fish-tail tube of Binnie. Two notches are cut half an inch deep, opposite each other, at one end of the tube. This is introduced into the lumen of the large duct and sutured in with catgut. The bile readily passes underneath the tube and out through the common duct into the duodenum to the extent which the obstruction permits, while the tube itself efficiently prevents any tension and keeps up free drainage. The tube in the gall-bladder, or in the commo duct, is attached by a piece of glass tube one and one-half inches in length to a short piece of rubber tubing, which leads to an eight-ounce flask, which acts as a bile receptacle and

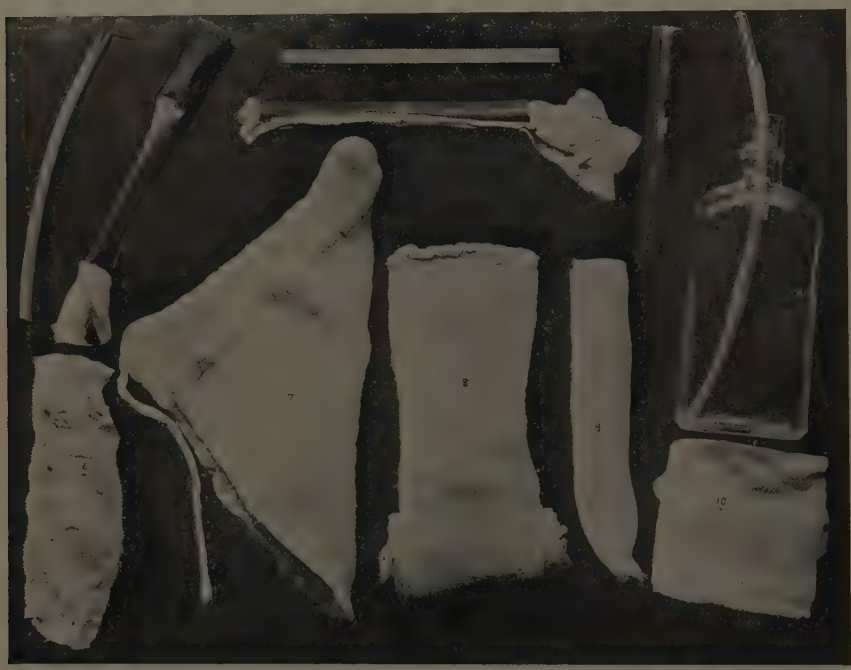

FIG. 518.—DRESSINGS IN GALL-BLADDER OPERATIONS.

1, Binnie's fishtail tube; 2, cigarette drain rubber tissue and gauze; 3, split rubber tube with gauze; 4, dressed rubber tube gall-bladder drain. One-fourth inch rubber tube wrapped in gauze and whole enclosed in rubber tissue; 5, bottle with drainage tube; 6, two-inch selvaged edge gauze strip; 7, large square gauze pad; 8, gauze roll; 9, small gauze sponge strip; 10, large gauze sponge.

is fastened into the dressings. A boiled bottle is used to replace the one in the dressings twice each day, or oftener when necessary.

For packing the intestines back from the field of operation squares of gauze should be provided. These are made eight by ten inches in size and composed of eight thicknesses with an identification tape. The space in front of the liver and about Winslow's foramen is protected with strips of gauze one yard in length and one-half yard wide, folded until they are four inches in width. These act as deep absorbents and are out of the way.

Preparation of the Patient, etc. for Operation.—The average patient, after a careful physical examination, enters the Hospital by

three o'clock the day before the operation, and is there given 2 ounces of castor oil in the foam of beer. At six o'clock the patient receives a light supper, and at nine o'clock a bath. By this time the oil has effectually acted, and if there has been any excess it has been carried off. We have found oil more effectual and less liable to drain large quantities of serum than saline laxatives. The patient receives no fluids or food on the morning of the operation, and the operations are completed before noon.

The operative field is shaved shortly before entering the operating room as a matter of convenience, but the entire preparation of the patient's skin is made during the administration of the anesthetic. It consists in washing with soap and water, paying particular attention to the navel; washing with 1:2000 bichlorid, followed by Harrington's Solution No. 9, for one-half minute, and finally with alcohol, 75 per cent. The alcohol is briskly rubbed into the skin for about two minutes. If there be any pustules, or if the skin is in a poor condition after using the alcohol, the entire area is painted with tincture of iodin, the incision being made directly through the iodin discoloration without its removal.

If the patient is very much jaundiced, we have followed the plan of Robson,[39] giving 80 grains of chlorid of calcium in divided doses each day for two days preceding operation. We are unable to say positively whether or not this has any particular influence in increasing the coagulability of the blood. We have not found a time coagulability test to have great practical merit. As a general rule, if there be purpuric spots in the skin of the patient, showing that the blood cannot maintain itself within the blood-vessels, operation should not be performed. Some cases with slow coagulability have no trouble from hemorrhage following operation. In others with rapid coagulation, operation will be followed by capillary oozing. It is evident that the blood is only one factor. A second of equal importance must be taken into consideration; and that is, the character of the blood-vessels and tissues. W. J. Taylor[40] recommends the internal administration of thyroid extract to prevent hemorrhage in cases of deep jaundice.

The field of operation is protected in the usual manner. Our rule is that the operator and assistants, after thoroughly disinfecting their hands and arms, should wear sterile rubber gloves and cotton sleeves.

The open-drop method of ether anesthesia is to be preferred, and in this connection it should not be forgotten that operative manipulation about the neck of the gall-bladder and common duct may cause a grunting respiration and spasm of the diaphragm which cannot be completely stopped by deep anesthesia without serious danger to the patient.

The Incision.—The incision which will be found most useful is the vertical one through the rectus muscle. Ordinarily, this should be made between the outer one-third and the inner two-thirds of the muscle. The incision should not be longer than is necessary to do the work, as every extra inch of incision means several days additional confinement to bed. The ducts must always be carefully explored by palpation, hence, unless the patient is thin, it is necessary to make an incision large

enough to admit the entire hand. In acute suppurative infections, in which considerable adhesions exist, it is not often a wise practice to break up these adhesions, on account of the danger of spreading the infection, but each case must be judged on its merits.

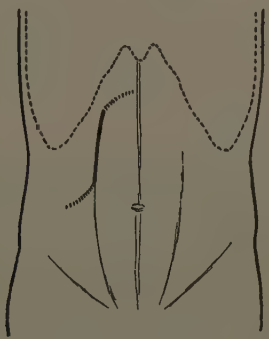

FIG. 519.—INCISION OF ARTHUR DEAN BEVAN FOR OPERATIONS UPON THE GALL-BLADDER AND BILE DUCTS.

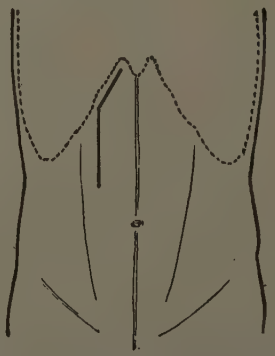

FIG. 520.—ROBSON'S MODIFICATION OF THE BEVAN INCISION.

To aid the work on the deep ducts the incision of Bevan[41] is by far the most useful. This consists of a vertical incision about the middle of the right rectus muscle, three or four inches in length, and is supplemented by cutting loose the inner half of the rectus muscle from the costal margin as far as the median line, and well up into the sternal notch. This latter detail has been emphasized by Robson, to whom we owe so much in surgery of the upper abdomen. At the extreme upper angle of this incision the anterior mediastinum may be opened, causing air to rush in and out, leading to the belief that the pleural cavity has been invaded.

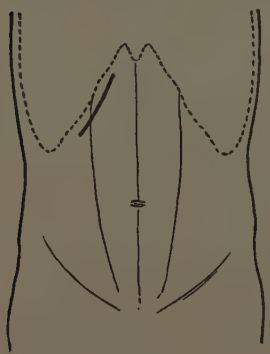

FIG. 521.—KOCHER'S INCISION.

Should the fundus of the gall-bladder lie far out, the lower angle of the incision is carried outward by Bevan in a similar manner, securing wide space. In carrying this out we have followed the recommendation of Weir,[42] in cutting the aponeurosis in front and behind the muscle, at the lower angle, and retracting the muscle itself without cutting its fibers.

The Kocher incision, parallel with the margin of the ribs, is preferred by Rutherford Morison and others. We have not found this incision as satisfactory as that of Bevan, and it has the disadvantage that if it is necessary in the after-treatment to use much packing it is especially prone to hernia. As Morison secures most of his drainage posteriorly, this has not proved a disadvantage in his hands.

In doubtful cases the duodenum and the stomach should be inspected, the right kidney palpated, and if there is pain in the region

of the appendix there should be direct palpation of that organ itself for evidence of disease.

In working on the deep ducts, the procedure of Robson, in which the liver is first pulled downward, and then the inner half of the right lobe brought well out of the abdominal incision by traction on the gall-bladder and margins of the liver by gauze sponges, enables the most extraordinary exposure of the entire field of operation, so that the common duct may be brought to the surface of the body. With a properly placed incision of sufficient size, this dislocation of the liver and exposure of its under surface gives results, the importance of which cannot be overestimated.

FIG. 522.—EXPOSURE OF UNDER SURFACE OF RIGHT LOBE OF LIVER, SHOWING GALL-BLADDER AND BILE DUCTS. (After the Robson method.)

The enormous incisions of Courvoisier and Kehr are wholly unnecessary, and are followed by a considerable liability to hernia.

Before suturing the abdominal wound, the mechanical elevator of the table should be lowered so that the patient lies flat, in order to relieve the tension on the muscles. In closing the incision, we prefer layer suturing with catgut, supplemented by one or more "figure-of-eight" silkworm gut sutures for the skin and the aponeurosis.

In all operations about the bile tract, before closing the abdominal incision, a very careful arrangement of the viscera should be made. The small intestines should not be allowed to come in contact with the infected area, *first*, because of their swaying movements, which would carry the infection throughout the abdomen, and, *second*, for the reason that if adhesions should form it might cause ileus. The stomach and

duodenum depend upon motility for their functions; therefore, they should be prevented from coming in contact with denuded areas and forming adhesions. This protection is furnished by the upper edge of the omentum and the transverse colon. These structures are carried upward and placed between the gall-bladder and ducts and the abdominal cavity; and, if necessary, they can be held in this situation by one or two catgut sutures.

Cholecystostomy.—Cholecystostomy we consider the normal operation for gall-stone disease. It is indicated in all cases in which the gall-bladder is not seriously damaged and in which the removal of the calculi will leave the cystic duct free, so that there will be no further trouble from inefficient drainage. Many prefer to remove the gall-bladder in this particular type, claiming that it is nearly as easy an operation and that it gives more satisfactory results. In our hands it has one-third of 1 per cent. higher mortality without any compensating advantage. In over eighteen hundred operations upon the gall-bladder and bile passages, in twelve hundred of which the gall-bladder was not removed, there was but a single case in which stones reformed in the gall-bladder.

In connection with diseases of the common duct, cholecystostomy is the operation of choice, and in all cases in which the ducts of the liver are infected, *first*, because bile drainage is an essential factor in the relief of the patient, and, *second*, for the reason that gall-stone disease of the deep ducts is especially liable to subsequent infections; and, if so, the gall-bladder is a reliable guide to the deep ducts. It is also most valuable for a cholecystenterostomy if benign stricture of the common duct should develop.

In performing cholecystostomy, a small abdominal incision is made, and after palpation of the ducts and examination of the gall-bladder, the fundus is drawn up into the wound as far as possible and carefully protected with gauze packs. If adhesions exist they should be separated to a sufficient extent to secure a working space on the fundus, and also on the inner side, to enable careful examination of the ducts; but it is not necessary to separate all of the adhesions, if they are apparently not injurious, as it opens up fields of infection and the adhesions will reform.

If stones can be felt in the cystic duct or pelvis of the gall-bladder an effort should be made to dislodge them before opening the gall-bladder.

An aspirating trocar of the Ochsner type is introduced and the bile and other contained materials rapidly drawn out, the puncture in the gall-bladder is enlarged, and the margins caught with several Carmalt forceps.

The cystic cavity is now mopped out with narrow, rolled strips of gauze, and the stones removed by means of scoop and forceps, using the finger as a guide. After careful evacuation, and re-examination of the ducts to see that no stones are left behind, a $\frac{1}{4}$ inch rubber drainage tube, wrapped with four layers of gauze and rubber tissue, is introduced

2 or 3 inches into the gall-bladder, and a purse-string suture of No. 1 (plain or iodized) catgut is run through all the coats of the gall-bladder, ⅓ of an inch below the opening, taking pains to pass underneath the blood-vessels. The loop is held on one side and the two ends on the other, and the cut margins of the gall-bladder are inverted and the catgut pulled tight, after the method of Summers,[43] bringing the peritoneal surfaces closely in contact with the rubber tube. With the same thread a second peritoneal stitch is passed around, and this again is drawn tight. The catgut will be absorbed in about four days, and as it will not be necessary to remove the tube for from six to eight days, it will not interfere with its removal.

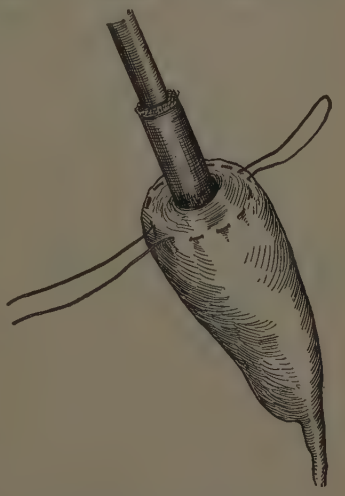

FIG. 523.—CATGUT PURSE-STRING SUTURE FOR COMPRESSING THE WALLS OF THE GALL-BLADDER TIGHTLY ON A DRESSED TUBE.

J. E. Summer's adaptation of Dawbarn's method to cholecystostomy.

The gall-bladder is finally sutured to the peritoneum at the upper angle of the incision, with from two to four catgut sutures, and the wound closed up to this point by layer suturing, supplemented by silkworm gut.

The peritoneal surfaces come at once in contact on removal of the drain, and, as a rule, bile discharge will cease in from twelve to forty-eight hours thereafter.

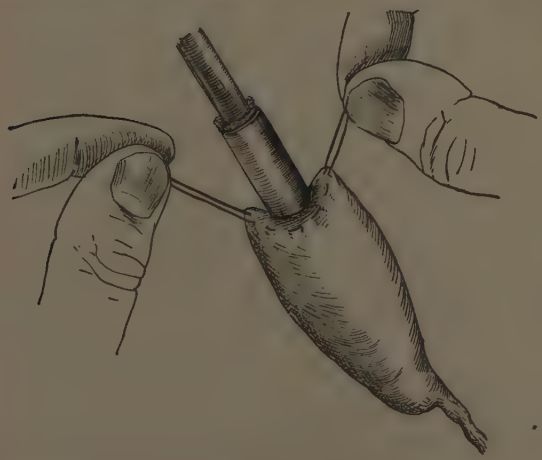

FIG. 524.—HOLDING PURSE-STRING WHILE INVERTING CUT MARGINS OF GALL-BLADDER OPENING.

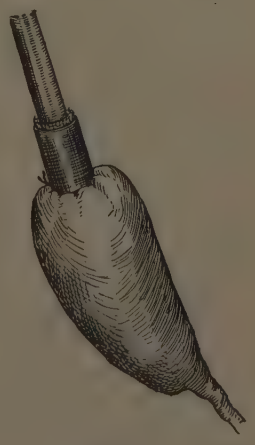

FIG. 525.—PURSE-STRING SUTURE TIED.

Drainage outside the gall-bladder is seldom necessary, but if so, it should be remembered that the liver is in constant motion by reason of the action of the diaphragm in breathing, and the drains have a great tendency to become misplaced. For this reason it is wise to anchor

them in proper position by a fine catgut suture, which will prevent displacement until adhesions are formed.

It may be necessary to vary this technic somewhat:

First, If the gall-bladder be very short and shrunken, and it is desirable to save it, a tube is introduced into its cavity and the gall-bladder stitched to and around it without inverting the edges. Several of these sutures should grasp both the gall-bladder and the gauze and rubber tissue, holding it firmly in position. Four strips of selvaged, 2-inch gauze are now sutured, each with a fine catgut suture, to the gall-bladder, just below its cut margin. The suture grasps the bit of gauze 1 inch from its end and the gall-bladder, and is tied between the gauze and the gall-bladder. On the liver side it is tied closely into the margin of the notch. The deep end of the gauze is now tucked down so that it surrounds the opening in the gall-bladder like a shirting, while the outer ends come up out of the wound about the tube at the upper angle. The remainder of the abdominal incision is closed in the usual manner.

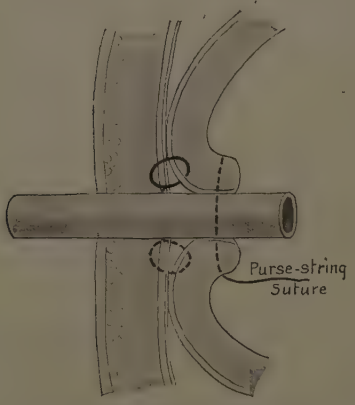

FIG. 526.—SECTIONAL CUT SHOWING THE GALL-BLADDER AND TUBE IN POSITION. (After Binnie.)

Second, It will sometimes be found that the gall-bladder has very rigid walls, infiltrated by recent infection, and so adherent as to become partially extraperitoneal. In this case a tube is introduced into the gall-bladder and around it is packed iodoform gauze, so that there will be no dead space.

Third, A gall-bladder may lie far to the outside, underneath the right lobe of the liver; the drain should then be brought out the loin through a counter-incision, after the plan of Morison.

Morison has shown that there is a considerable-sized pouch in front of the right kidney which in some subjects will contain a pint of fluid before it will overflow into the abdominal cavity. Brewer[44] has shown that the capacity of Morison's pouch varies, and is largely determined by the height of the peritoneal attachment of the ileocecal intestinal coil to the ileum.

Fourth, In subacute infections, the thin-walled gall-bladder is greatly distended with bile, foul-smelling from colon infection. There is a great tendency for recurrence of the symptoms at a later date; after much suffering, the fistula will reopen and evacuate the contents of the distended and obstructed gall-bladder. For this reason the gall-bladder should be sutured to the exterior aponeurosis of the rectus muscle instead of to the peritoneum. This forms a fistula which is much slower to heal, and in case of relapse the discharge readily works its way to the surface.

Ideal Cholecystostomy.—This operation was proposed by Langenbuch,[45] but has been to a very large extent abandoned. It consisted in opening the gall-bladder, removing the stones, and then suturing it completely and dropping it back into the abdomen. There are two serious defects in this method. *First*, it does not provide drainage for the infected mucous membrane, and, *Second*, it is occasionally followed by perforation and death. It has, however, a small field of usefulness; *i. e.*, when stones are accidentally discovered during the course of other operations, in which the gall-bladder is otherwise normal, and there are no evidences of infection.

It is safer, even in these cases, to follow the technic of Kocher, and after closing the gall-bladder attach it to the peritoneum at the bottom of the incision, carrying a small drain down to this point, so that should the sutures not prove effective, it will spontaneously discharge to the surface rather than into the peritoneal cavity.

Stones Impacted in the Pelvis of the Gall-bladder.—If the obstruction is complete the gall-bladder should usually be removed. Rarely it may be desirable to save such an organ. If so, the stone is extracted through the gall-bladder, if possible. If not, an incision is made down upon the stone, and after removing it the incision should be sutured. A piece of 2-inch gauze is anchored over the closed incision in the pelvis of the gall-bladder, and outside of this a piece of rubber tissue should be placed and an ordinary cholecystostomy performed.

Stones in the Cystic Duct.—Stones in the cystic duct usually indicate cholecystectomy, but if by reason of infection of the deep ducts it is desirable to save the gall-bladder, the cystic duct should be exposed and incised in its longitudinal axis and the stone removed. The cystic duct should be closed with one or two catgut sutures and this line of suturing should be protected by a strip of 2-inch, selvaged gauze, tacked to the duct by fine catgut stitches.

Stones in the ducts should not be crushed, as fragments left behind may become the nuclei for new stone formations, and the duct walls may be injured, causing stricture.

The mortality of cholecystostomy is about 1½ per cent.

Cholecystectomy.—Cystectomy is indicated in all cases in which the cystic duct is insufficient to afford drainage.

The gall-bladder should also be removed in all cases in which it is thick-walled and possibly the seat of malignant disease, and in those in which, as the result of disease or injury, it will not become a fit receptacle for bile.

Cystectomy was first proposed by Langenbuch in 1882, but it was not popularized until within the last decade. It is performed in the following manner:

An incision 3 or 4 inches in length is made through the right rectus muscle, and, if necessary, carried upward to the median line. The hand is introduced into the abdomen and the liver drawn downward and forward by traction upon the gall-bladder and margin of the liver with pieces of gauze, exposing the under surface after the Robson

method. The peritoneal cavity is carefully protected by moist gauze pads, both squares and rolls. A curved clamp is placed upon the fundus and this is drawn upon and the gall-bladder straightened out; then a second and a third clamp are similarly used, until the cystic duct is exposed in its mesentery. The clamps are now removed, except the one which holds the pelvis of the gall-bladder, and an incision is made through the peritoneum around the cystic duct at the point of obstruction. With the handle of the scalpel the cystic duct is thoroughly exposed and grasped with a curved artery clamp; a second is placed on the gall-bladder side, and the duct divided between the two. The

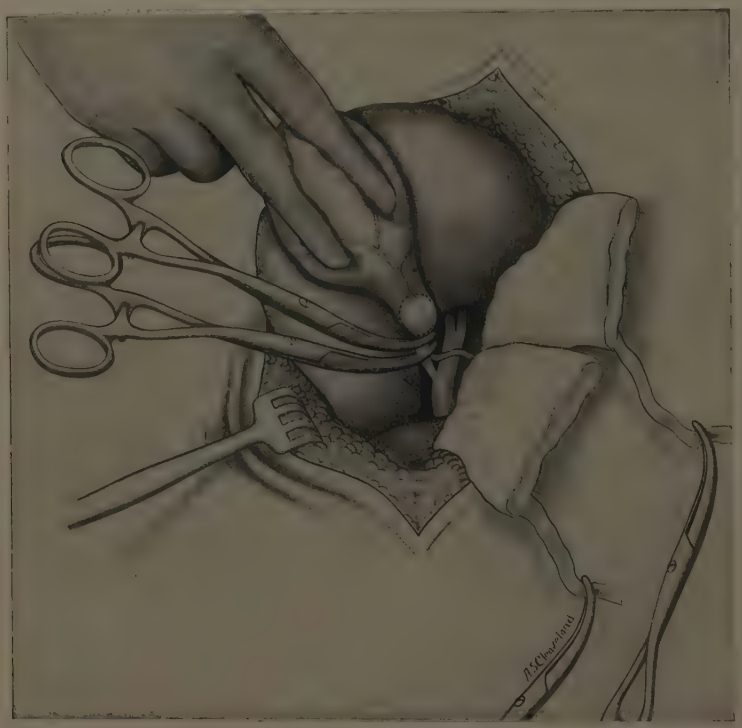

FIG. 527.—CHOLECYSTECTOMY.
Showing clamps applied to cystic duct and cystic vessels.

peritoneum of the lateral margins of the gall-bladder is incised on each side so as to leave flaps. Traction is now made on the forceps holding the cystic duct, next to the gall-bladder, and as this is drawn upward the cystic artery is exposed, grasped with clamps, and divided. The finger is now introduced into the cellular space between the two folds of the peritoneum, and the gall-bladder gently detached from the liver. When in this way the gall-bladder has been separated nearly to the fundus, it is then used as a tractor to steady the liver until the cystic duct and artery can be tied securely with catgut on a small curved needle. The two peritoneal flaps are whip-stitched from below upward as far as the gall-bladder has been separated. This completes the deep

and most difficult part of the operation, and secures the blood-vessels early, preventing hemorrhage. The separation of the gall-bladder is continued in the same way until it is removed and the peritoneal flaps are stitched across the cellular space which has been exposed in the notch of the liver. A small split rubber drain is now carried down to the stump of the cystic duct, the gauze pads removed, and the incision closed in the usual manner.

It is wise to fasten this drain in position with a fine catgut suture. This is done by catching the peritoneal flaps with fine catgut stitches and tying these to the tube which should be introduced in such a manner

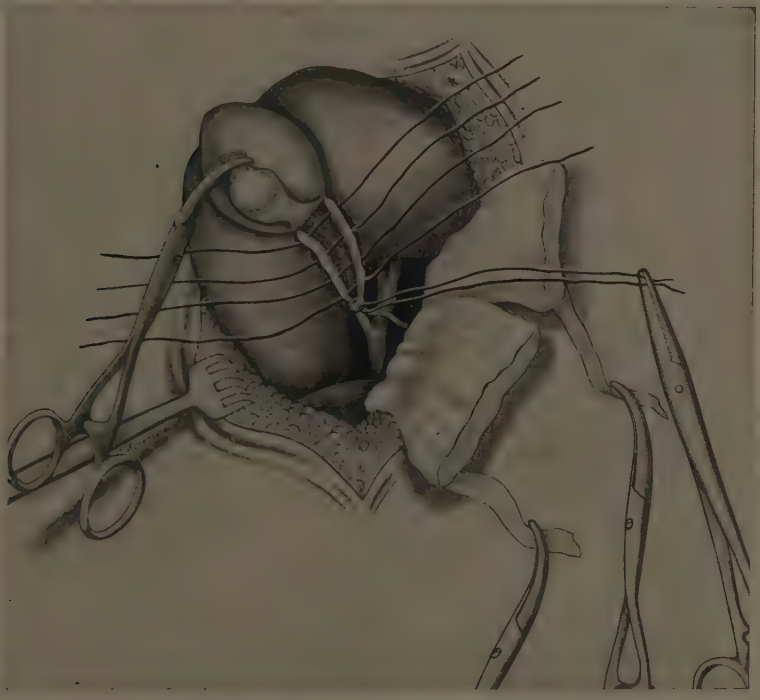

FIG. 528.—CHOLECYSTECTOMY.
Showing cystic duct and vessels ligated. Gall-bladder partially separated and sutured in position to cover the exposed liver substance.

that the split in the tube with its exposed gauze is turned toward the liver. It should be borne in mind that the liver is stretched when the tube is introduced and that some shortening takes place on reduction; therefore, some care should be exercised not to introduce the tube so deeply that it will compress the common duct. The drain is removed in from four to eight days; it is not necessary to introduce a second drain. Some operators dispense with this drain entirely, but the writers have known leakage to take place from a stump of the cystic duct through the drainage channel as late as ten or twelve days, long after the removal of the drains.

There are numerous variations of the operation herein described.

Many prefer to start at the fundus of the gall-bladder, divide the peritoneum on each side, and gradually dissect it free from the liver until the cystic duct and artery are drawn well up into the wound, when they are ligated and the operation completed as before.

When dense adhesions exist about the neck of the gall-bladder and common duct, this latter method is often advisable, the finger being placed in the gall-bladder during the deep dissection to prevent injury to important structures.

In our earlier operations we often removed the mucous membrane of the gall-bladder. We never had any unfavorable results from the method, yet it has but a limited field of usefulness. It is performed by splitting the gall-bladder from the fundus to the cystic duct. The mucous membrane is shelled out with the handle of the scalpel. The excess of tissue being cut away, the remainder of the operation is similar to that of typical cystectomy.

When it is necessary to remove the gall-bladder, drainage of the bile to the surface still seems to be desirable, as an additional safeguard. The operation is completed as before described, except that the distal end of the cystic duct is split for one-fourth of an inch into two equal parts, and a catgut suture is placed each side so as to anchor tube and drains to the duct, which is left open.

The tissues are sometimes very friable, and on account of adhesions secure ligation of the cystic duct and artery is difficult. In these cases forceps should be placed upon the duct and cystic artery, the gall-bladder dissected out, and the forceps left in place for forty-eight hours. They should be unlocked six hours before they are removed, as the tissue in the grasp of the forceps becomes devitalized and firmly embedded in the serrations, and if removed at once upon unlocking the end of the blood-vessel may be torn off, causing hemorrhage. The forceps, which furnish most excellent drainage while in position, should be surrounded by several thicknesses of two-inch selvaged gauze. The gauze should not be disturbed at the time the forceps are removed, but loosened several days later.

In removing the gall-bladder the liver may be so seriously denuded as to cause a great deal of venous oozing. This is easily controlled by introducing catgut sutures one-half inch or more back from the cut margin of the liver, passing them completely behind the bleeding surfaces, and out on the opposite side. These may be put in as continuous or as interrupted sutures, using a non-cutting needle. Care should be taken that they are not drawn so tightly that the friable border of the liver is cut. It takes very little pressure to check the bleeding. Sometimes it may be necessary to pass down several thicknesses of gauze and compress it into the bleeding surface of the liver by the catgut sutures.

In cholecystectomy for cancer, a V-shaped gutter should be cut into the margin of the liver and removed with the gall-bladder and tumor. This incision is readily closed by the introduction of catgut sutures as described above, with gauze protection.

The mortality of cholecystectomy for gall-stone disease is less than 2 per cent.

In the after treatment of cases of cholecystectomy the stomach tube is of the greatest importance. When the patient continues to vomit a greenish or dark liquid after twenty-four hours, gastric lavage should be promptly employed. Acute dilation of the stomach and retention of poisonous products is particularly prone to follow this operation, and the early and repeated use of gastric lavage in cases that are not making satisfactory recovery is most important.

Operations upon the Common Duct.—These operations require very thorough exposure. The liver should be rotated well out and the ducts brought as near as possible to the surface. High division of the inner half of the rectus muscle up into the sternal notch is of the greatest value in effecting this maneuver. After careful gauze protection the gall-bladder should be drawn out of the wound, and if it contains stones and fluids should be emptied, a piece of gauze packed in its cavity, the incision in the gall-bladder, with the gauze, being caught with a pair of forceps to prevent leakage. The gall-bladder will probably be shrunken and possibly almost obliterated. In most cases, however, it can be grasped with one or more pairs of clamps and used to steady the common duct. The hand is introduced into the abdomen and if stones are present, one is caught between the thumb and finger and brought into the exposed supraduodenal common duct space. By steadying the stone with the thumb and forefinger of the left hand two traction sutures are introduced, parallel with the long axis of the duct, grasping laterally about one-half inch of its wall; the stone being used like a stocking-ball. The ends of the threads are caught on each side with forceps, and used as tractors. The thumb and finger still continue to hold the stone firmly against the anterior-inferior margin of the duct. An incision is now made of sufficient size to extract the stone without crushing. The duct is examined for other stones; if found, these are brought up in the same way and extracted with a scoop. The scoop is now passed up into the hepatic ducts, and stones, if present, gently extracted. It is then passed down into the distal end of the common duct, and stones, if present, are brought out. If possible, the finger is then introduced into the common duct and carried well up into the hepatic duct to the primary division. If stones are present they are coaxed out by a stripping motion of the finger, a slight vacuum being thus created, which, as a rule, will bring the stones down behind the finger. The finger is then passed down into the distal extremity of the duct, and with the thumb and two fingers of the right hand below the duodenum and pancreas to steady the parts, the lower end of the duct is carefully palpated with the finger within its lumen.

After the stones have been entirely removed, a fish-tail tube, which is made by cutting two notches on opposite sides of a one-fourth inch rubber tube, is placed in the duct at a right angle and caught with a fine catgut suture.

If any bleeding exists at the angle of the duct incision it is checked

by fine catgut, but no attempt is made to close the opening in the duct accurately.

If the bile is comparatively healthy and the duct is in good condition no sutures whatever are introduced, a split rubber tube drain being carried directly down to the duct opening; about this, two cigarette drains are placed. A third cigarette drain is carried down into the kidney pouch and brought along the outer wall of the gall-bladder through the external incision. If the gall-bladder has been opened, a drain is introduced into it after the plan of an ordinary cholecystostomy. The drains should be secured in place by fine catgut sutures.

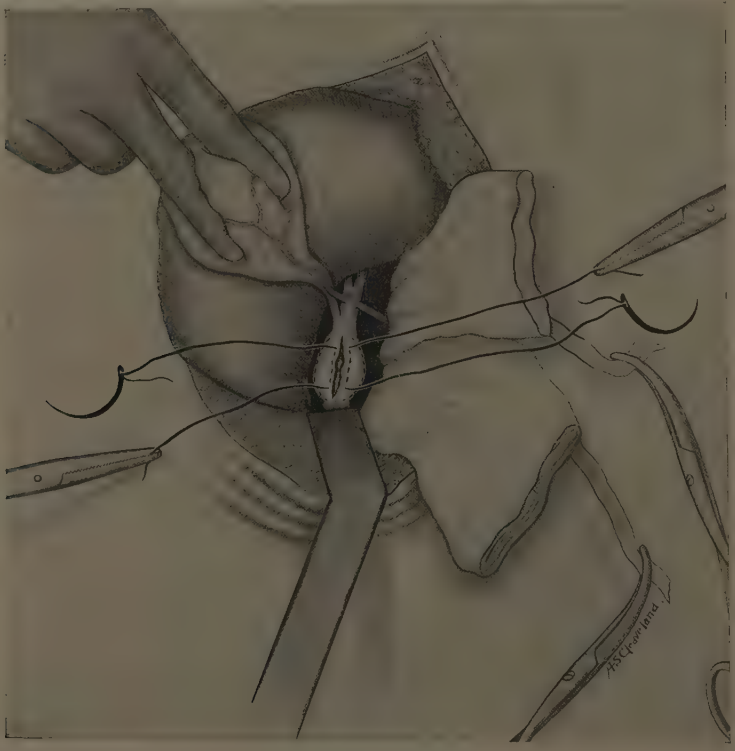

FIG. 529.—CHOLEDOCHOTOMY.
Showing method of placing working sutures in common duct.

If the cystic duct is widely dilated, so that a rubber tube can be carried through the gall-bladder and cystic duct into the common duct, the incision in the common duct may be completely sutured, not otherwise. Free drainage of the bile to the surface contributes more to the safety of the patient than any other one feature of the operation. The drains are usually removed at the end of a week. Sometimes they are left for from ten to twelve days. It is not necessary to re-introduce drainage material, although if the drainage opening is large a strip of gauze may be carried to the bottom and changed once or twice each day.

The tubular drain in the common duct should be connected with a bottle in the dressings by a short piece of glass and rubber tubing.

There are a number of variations of this operation. The common duct may be completely buried in a mass of adhesions and the anatomy so obscured that it would require a tedious and bloody dissection for complete exposure. In these cases the hand should be introduced into the abdomen and the stone found and brought up close to the cystic duct. The stone is held sufficiently tight to cause the structures in front to become prominent, and an incision carried down to it directly through the adhesions, care being taken to see that important structures are kept well aside. When the stone is exposed, the side walls of the duct are grasped by holding clamps to control the duct, the stones removed and drainage established as before.

If the patient is in bad condition the two forceps may be left in position attached to the duct for forty-eight hours, gauze drainage material, cigarette drains, etc. being placed about them.

Stones impacted in the retroduodenal, or second portion, of the common duct can nearly always be slipped backward to the point of election for removal. With a good opening in the common duct and a finger within its lumen, we have seen but 2 cases in which a stone impacted in this situation could not be worked up to and out of the incised duct.

In these cases Kocher[46] first advised that the peritoneum along the right margin of the duodenum be divided and the bowel loosened from its bed exposing the duct behind it, which is then incised and the stone removed. This operation has a very small field of usefulness. The duodenum is very liable to be injured, leading to a fistula, and the pancreas also may be seriously damaged.

Every effort should be made gently to carry the stone either backward into the supraduodenal portion or forward into the ampulla, where it can then be extracted by the transduodenal route.

Duodenocholedochotomy.—This is the operation of McBurney,[47] and has a considerable field of usefulness for the removal of stones impacted in the ampulla.

The operation is performed as follows:

The common duct is exposed as before described, and the abdominal cavity very carefully protected with gauze, leaving the upper four inches of the duodenum and pylorus exposed. If stones exist in the gall-bladder they should be first removed; if in the upper portion of the common duct, the duct should be incised and the stones removed from it.

The stone in the ampulla is grasped with the thumb and forefinger of the left hand and brought close up against the anterior wall of the duodenum which is now incised, and the secretions escaping from the duodenum carefully mopped up. The margins of the cut in the duodenum are grasped with forceps on each side. An assistant gently pulls these apart, and the stone can be plainly seen lying behind the tense mucous membrane of the posterior wall of the duodenum, just above

the papilla. The overlying mucous membrane is cut and the stone extracted. As a rule, it is not necessary to put a stitch in the posterior incision, unless it has been extensive, in which case it should be of catgut tied on the mucous surface.

If other stones are in the common duct they are brought down and out. If the common duct has been incised in the supra-duodenal portion for the removal of stones, a gall-stone scoop is passed from the incision in the supraduodenal portion of the common duct down through its lumen and out into the duodenum, and all stone fragments removed.

In some cases a piece of gauze may be drawn from the incised duct down and out through the duodenum. The incision in the anterior wall of the duodenum is now closed with two rows of sutures, and the common duct drained as before described.

If the common duct has not been incised, the stone in the ampulla having been the only one, it is not necessary to make a special opening in the common duct for the purpose of drainage. This will be freely accomplished by way of the duodenum. After most thorough hemostasis, the abdomen should be closed without drainage, or, if there has been any soiling, drainage may be established by the introduction of a little roll of rubber tissue, which is brought out through the upper angle of the abdominal incision.

On placing the patient in bed one or two quarts of half-strength normal salt solution should be slowly introduced into the rectum by means of a female douch point with a number of openings, the tip of which should be carried just above the internal sphincter muscle. The container of the solution should be raised about six inches. From one-half to an hour should be taken for the introduction of each quart. When patients are in bad condition from jaundice, etc., we have found this method of Murphy just described to be of great value; introducing into the system in this way during the first twenty-four hours from three to six quarts of water for flushing purposes, the kidneys begin to act freely and the pulse rapidly improves.

The use of the stomach-tube and warm gastric lavage to relieve accumulation of fluids in the stomach is most important in the after-treatment.

Stones in the Hepatic Duct.—Gall-stones in the hepatic ducts usually have their origin in the gall-bladder and have been carried upward into the dilated duct; a gall-bladder stone nearly always forms the apex of the common duct obstruction. Under such circumstances, stones of hepatic origin may also be found in the hepatic ducts. Hepatic duct calculi are usually dark-colored, brown or black, disc-shaped concretions of small size, although occasionally they will be found as large as a lima bean. The ducts of the liver may contain hundreds of such calculi.

The common duct is opened in the usual situation and after removal of all stones possible, a pair of forceps should be passed down through the common duct, and out of the papilla, which should be thoroughly

dilated, without laceration, the object being to provide ready escape for the liver duct stones which will be washed down and out following the removal of the obstruction.

If the papilla cannot be dilated in this manner the incision in the common duct should be made large, and left entirely open for the escape of the stones externally.

Occasionally, a large stone formed in the gall-bladder becomes caught in an hour-glass constriction in one of the primary divisions of the hepatic duct and causes great difficulty in removal. We have adopted on such occasions two different plans: *First*, to carry the incision in the common duct up through the hepatic duct with dull-pointed scissors until the stones could be grasped; *Second*, to crush the stone and remove it piecemeal.

Cancer of the Common Duct.—The typical carcinomatous tumor of the common duct is a hard, grayish-white, well-defined growth, which during the operable stage will seldom be found larger than the terminal joint of the forefinger. It is of such stony consistency that it is sometimes mistaken on exploration for a stone, until incision determines its true character. In two-thirds of the cases the neoplasm will be found in the terminal portion of the common duct, and if seen sufficiently early, may be removed by the transduodenal method, after the plan described for the removal of stone. Several interrupted catgut sutures, so placed as not to permit of interference with drainage, should be introduced to close the defect. Successful operations of this kind have been reported by Halsted,[48] Edes,[49] Robson, and Mayo.[50]

Carcinoma higher up in the common duct should be directly excised, if possible. The duct should be anastomosed by end to end catgut sutures, leaving a defect in the suturing on the anterior-inferior margin to permit of drainage. A small number of successes have been reported by Moynihan[51] and others. Three operations by the writers gave 2 recoveries and 1 death.

If the excised section of the common duct is too long to permit of end-to-end union, the distal end is ligated and the proximal portion re-implanted in the duodenum in a situation where the intestine is entirely covered by the peritoneum. We have practised two methods in carrying this out.

The simpler method is to make a working incision 1 inch long in the duodenum, through which a pair of curved forceps is introduced and made prominent at the site of the proposed anastomosis. A small incision is here made, the forceps passed out, and the cut end of the duct caught. This is drawn slightly within the lumen of the duodenum and two catgut sutures introduced laterally between the duct wall and the duodenum. By slight traction on the forceps, the walls of the duodenum and the duct are advanced into the intestinal lumen, ¼ inch, forming a nipple, and three catgut and one fine linen sutures are introduced between the outer coats of the duodenum and the duct, holding it firmly in position. Rolled rubber tissue drainage is intro-

duced, if the field has been soiled. After closing the working incision in the duodenum the abdominal incision is closed to the drains.

The Second Method.—When the duct is greatly dilated, an elliptic piece may be removed from the side wall of the duodenum where it is entirely covered with peritoneum, and the dilated duct sutured to this orifice by two rows of catgut sutures in the same manner as a gastro-jejunostomy is performed. The outer row of sutures is placed first, penetrating the outer walls of the duct and duodenum, behind, through-and-through catgut suture is carried all the way round and the outer row brought forward to the starting point. In 1 case we were able to use this particular method of anastomosis between the hepatic duct and the duodenum, after removal of the entire supraduodenal portion of the common duct, with success.[52]

Operations for strictures of the common duct are sometimes required. Two methods are available:

First, complete division of the duct proximal to the obstruction and re-implantation of the duct end into the duodenum; *Second,* and preferably, by cholecystenterostomy, if the gall-bladder and cystic duct are sufficiently patulous for the purpose.

Moynihan reports a case in which a plastic operation was performed, removing for this purpose a flap from the stomach, which was left attached at its base, and used to fill the gap in the common duct. Studenrauch[53] reports a successful operation of this character, and has devised a series of theoretical plastic operations for the purpose of repairing defects in the common duct, which are very ingenious, but have not been tried on a human subject.

Cholecystenterostomy.—Cholecystenterostomy is an operation which has a considerable field of usefulness, both for radical cure and for palliation. It sometimes happens that a stricture is formed in the common duct below the cystic duct, which cannot of itself be safely removed, and if the cystic duct is sufficiently patulous and the gall-bladder in a fairly good condition, the bile may be diverted in this way into the intestine.

Unless the obstruction is complete there is a tendency for the opening to cicatrize, and in case the obstruction should become entirely relieved the probabilities are that complete closure of the artificial opening will take place. In chronic pancreatitis, in most instances, reliable drainage cannot be produced to last a sufficient length of time for cure, as the drainage through the common duct is very variable and the tendency would be for the stoma to become obliterated, but in cases in which the obstruction is permanent from any cause, whether benign or malignant, and it is not considered advisable to make a radical operation for the restoration of the canal, this particular procedure is indicated.

Should the patient have a biliary fistula to the surface of the body through which all the bile is discharged, and in which radical operation for the restoration of the lumen of the common duct is not considered advisable, cholecystenterostomy furnishes a safe method of relief.

In performing this operation, after the usual incision and gauze protection of the abdominal cavity, the inner aspect of the fundus of the gall-bladder should be joined to the duodenum, at a point about 2 or 3 inches below the pylorus.

In case the duodenum is bound down so that it is impossible to safely effect an anastomosis, a variety of methods have been practised. Kehr[54] united the gall-bladder to the stomach just above the pylorus, and he reports that no discomfort was experienced from the presence of bile in the gastric cavity.

A loop of jejunum may be selected, but if this is done it is wise to follow the plan of Mikulicz, and, after making the anastomosis between the gall-bladder and the intestine, join the two arms of the loop by an entero-anastomosis.

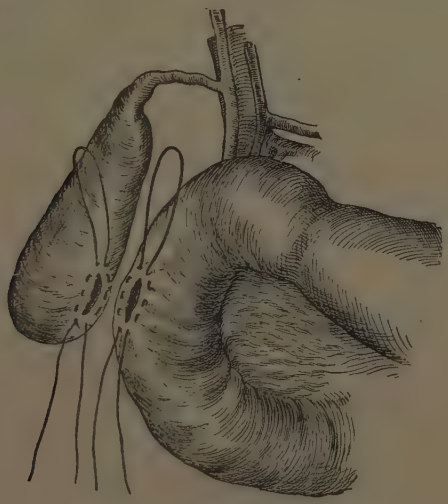

FIG. 530.—CHOLECYSTDUODENOSTOMY.
Circles suture introduced and incisions made.

The third method is to use the transverse colon at the hepatic flexure. Theoretically, this would appear to be a bad operation. The bacteria in the colon are exceedingly active, and, as shown by Bond,[55] the danger of an ascending infection of the liver through reverse mucous currents would appear to be great. However a very considerable number of cases have been reported in which the results, both immediate and remote, were satisfactory. In one patient of our own there has been no recurrence during over nine years since the operation. The mechanical washing effects of the bile seem to be sufficient to prevent the entrance of micro-organisms. The influence of the bile in intestinal digestion is very important. Its mechanical and emulsifying power and the stimulating effect it has on the pancreatic secretions are most valuable, and these are lost, but the fluid is re-absorbed from the cecum, and the bile pigments continue to have a stimulating effect upon the large intestine.

Anastomosis with the large intestine is very easy. The fundus of the gall-bladder and the hepatic flexure of the colon are normally in contact, and the site of union can be very nicely protected by the epiploic appendices and the omentum. In a few cases in which we have been unable to use the duodenum, we have employed the hepatic flexure of the colon with satisfaction, but every reasonable effort should be made to secure union between the gall-bladder and the duodenum.

The method of anastomosis preferred by the large majority of operators, ourselves included, is by the use of the Murphy button, which is applied in the usual manner, but this union should be protected by four or five interrupted mattress sutures of linen or silk, so introduced that although they catch the tissues very firmly, the knot

FIG. 531.—CHOLECYSTDUODENOSTOMY.
Each half of the Murphy button in place ready for union.

will lie close to the button and will be passed off with it. If the gall-bladder is already open the duodenum is brought up alongside, and after introducing the female half of the button and fastening it with a purse-string suture, the male half is introduced into the gall-bladder and a small incision made through which the barrel is slipped, the body of the half-button remaining drawn tight against the opening on the inside of the gall-bladder. The union is now made, the protecting sutures introduced, and the open end of the gall-bladder is closed, first, by purse-string suture of catgut through all the coats, turning the serous surfaces in contact, and around this a second circular suture of linen is placed. The area is now carefully wiped with a moist gauze swab and dried. If there has been extensive soiling from escape of contents of the gall-bladder or duodenum, one or two drains of rolled rubber tissue are introduced at some little distance, however, from the line of anastomosis.

The method which is preferred by Robson, Moynihan, and others is to make a suture anastomosis in which the fundus of the gall-bladder is brought along the side of the duodenum and united posteriorly at the site of the proposed union by a seromuscular suture of linen, one and one-half inches in length. An incision is then made in the fundus of the gall-bladder and in the duodenum, one-sixth of an inch in front of this suture. A chronic catgut suture is then introduced uniting the entire thickness of the posterior wall in front of the seromuscular suture and carried completely around to the starting point. The linen suture is then continued over this, around to its origin, the operation being identical in nature with that used in gastrojejunostomy.

The operation of *choledochostomy*, or union between the common duct and the skin, has been performed under certain very rare conditions in which the duct was enormously dilated. The operation has almost

FIG. 532.—CHOLECYSTDUODENOSTOMY.
Placing of the protective mattress suture outside of the Murphy button.

no field of usefulness. In the rare cases in which it may be indicated, attachment of the common duct to the duodenum by a *choledochenterostomy* should be performed instead. The anastomosis should be a lateral one, and can be most easily effected with a small Murphy button, or, if thought desirable, by suture.

Complications and Secondary Conditions.—*Acute perforation* of the gall-bladder and bile ducts into the free peritoneal cavity should be treated by prompt laparotomy with closure of the perforation and free local drainage. In addition, a counter-puncture should be made, and a glass drain introduced into the pelvis, just above the pubes. The patient is then placed in a semi-sitting posture, which is maintained for several days, to aid gravity drainage.

Internal intestinal fistulæ, causing obstruction or other symptoms, should be divided, and both ends turned in by carefully placed sutures.

Spontaneous fistulæ between the biliary apparatus and the surface of the body will usually be found to contain calculi in some portion of the fistulous tract. They are most frequent in the loin or appendical region, but we have seen them in the vicinity of the umbilicus, and even in the suprapubic territory. Before operating upon these fistulæ, they should be injected with a watery solution of methyl-blue, as recommended by Ferguson. The blue staining enables one to follow the various ramifications of the fistulous tract until the foreign bodies have been found and removed.

Post-operative Complications and Secondary Conditions.—*Mucous fistulæ* following cystostomy, are due either to failure to remove a stone impacted in the neck of the gall-bladder, or to stricture which has followed the ulceration produced by prolonged lodgment of the stone. The gall-bladder should be removed to a point beyond the obstruction.

Biliary fistulæ following cholecystostomy are usually due to failure to remove all of the stones. If the bile discharge is moderate in amount and intermittent, it is probably due to stone in the gall-bladder or cystic duct. If the discharge is very copious, the obstruction probably lies in the common duct, either from stone or thickening of the head of the pancreas, which compresses the duct. Cure is brought about by removal of the stone, or, if caused by chronic pancreatitis, the prolonged drainage of bile to the surface will of itself cause shrinking of the pancreatic enlargement and restoration of the lumen of the duct.

If a stricture in the common duct exists, as sometimes happens from prolonged lodgment of the stone, which has resulted in ulceration and cicatrization, cholecystenterostomy, or direct attack upon the obstruction, will be necessary for relief.

Bad technic may lead to biliary fistulæ, as for instance, a cholecystostomy in which the gall-bladder is attached to the lower angle of the abdominal incision, permitting bile to escape in certain attitudes of the body, or in which the gall-bladder is sutured to the skin, causing a mucocutaneous fistula. These fistulæ can be readily closed by cutting the gall-bladder free from its attachments and performing cholecystostomy, as before described.

Intestinal adhesions giving rise to symptoms of obstruction or severe colic should be divided and the method of Wyllys Andrews[56] followed, the transverse colon being lifted upward and so attached as to come in contact with the raw surfaces and prevent angulation or fixation of organs like the stomach or duodenum which depend on motility for their function.

Post-operative adhesions sufficient to give rise to serious trouble are rare, and the symptoms, when produced, are mechanical, as a rule, coming on in well-defined attacks, possibly attended with great pain, which resembles gall-stone colic. The condition is usually due to kinking of the ducts, which should be relieved by division of the adhesions and thorough freeing of the biliary channels. The transverse colon should then be transplanted upward and a small drain of rolled

rubber tissue introduced to carry out the blood and serum during the first forty-eight hours and prevent a deposit of plastic material.

Post-operative neuroses should be sharply differentiated from mechanical interference from adhesions. In the neurotic group the patient complains of a painful dragging and soreness in the region of the scar, which is not, as a rule, permanently relieved by operation. The disturbance is rather constant and does not come on in distinct attacks. While a source of great discomfort to the patient, the symptoms may be expected to disappear under the usual measures for the relief of neurasthenia.

These patients frequently present themselves with the scars of a number of operations which have been made for adhesions, with but temporary relief, the failures causing a bad mental condition, characterized by great despondency over the supposed incurable nature of their trouble. It is far better to tell such a patient the entire truth, while he still has confidence, and assure him that in a reasonable length of time he can be relieved by exercise, hydrotherapy, massage, etc., and avoid unavailing operations.

Hernia sometimes follows operations upon the gall-bladder and bile ducts. This should be avoided by carrying the incision upward rather than downward, so that it will be protected by the underlying liver, and also by careful suturing of the lower angle of the wound.

If such hernia occur some form of overlapping operation will be found most useful. The protrusion is sometimes of enormous size and most difficult of closure. Occasionally a wire filigree, as recommended by Bartlett,[57] may be necessary. It is placed between the margins of the peritoneum which are loosened for the purpose and the under surface of the aponeurosis and muscles which surround the hernial opening.

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CHAPTER LI.

SURGERY OF THE PANCREAS.

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Anatomy.—The pancreas lies across the posterior abdominal wall behind the peritoneum, at the level of the first and second lumbar vertebræ. Its larger end, or head, rests in the hollow of the duodenal loop. Connected with the anterior surface of the head of the pancreas by the neck, the body of the organ stretches away to the left behind the stomach, while its tapered extremity or tail usually comes into relation with the hilum of the spleen.

The common bile duct passes downward, buried among the lobules on the posterior surface of the head, between it and the second part of the duodenum.

Helly[1] has studied the exact relationship of the bile duct to the head of the pancreas. He finds that the lower end of the duct is in contact with the gland for a distance varying from 2 to 7 cm. In 37.5 per cent. of cases examined the duct was placed in a groove on the posterior surface of the head; in 62.5 per cent. the duct was completely surrounded by the substance of the gland. Out of 58 dissections by Bunger the bile duct ran through the substance of the pancreas in 55, and in only 3 was it uncovered. In 13 out of 20 cases in which I dissected the bile duct the lobules of the pancreas had to be divided before the common bile duct could be exposed; in 7 the duct was merely lying in a deep groove, though overlapped by the lobules of the gland.

The superior mesenteric vessels emerge beneath the neck and pass over a prolongation of the head known as the uncinate process.

The body of the pancreas lies behind the peritoneum of the lesser sac. The splenic artery runs a tortuous course along its upper border, while behind it, at a slightly lower level, is the splenic vein. In front, separated from it by the lesser sac of the peritoneum, is the stomach; while along its lower border is the attachment of the transverse mesocolon. The main duct of the pancreas, or duct of Wirsung, runs from left to right and terminates by emptying into the second part of the duodenum, in close association with the common bile duct. According to Letulle[2] and Nattan-Larrier, the duct of Wirsung may open into the common bile duct a variable distance from the intestine (type 1). Both common bile duct and pancreatic duct may open into a definite ampulla of Vater, which has a single opening leading into the duodenum

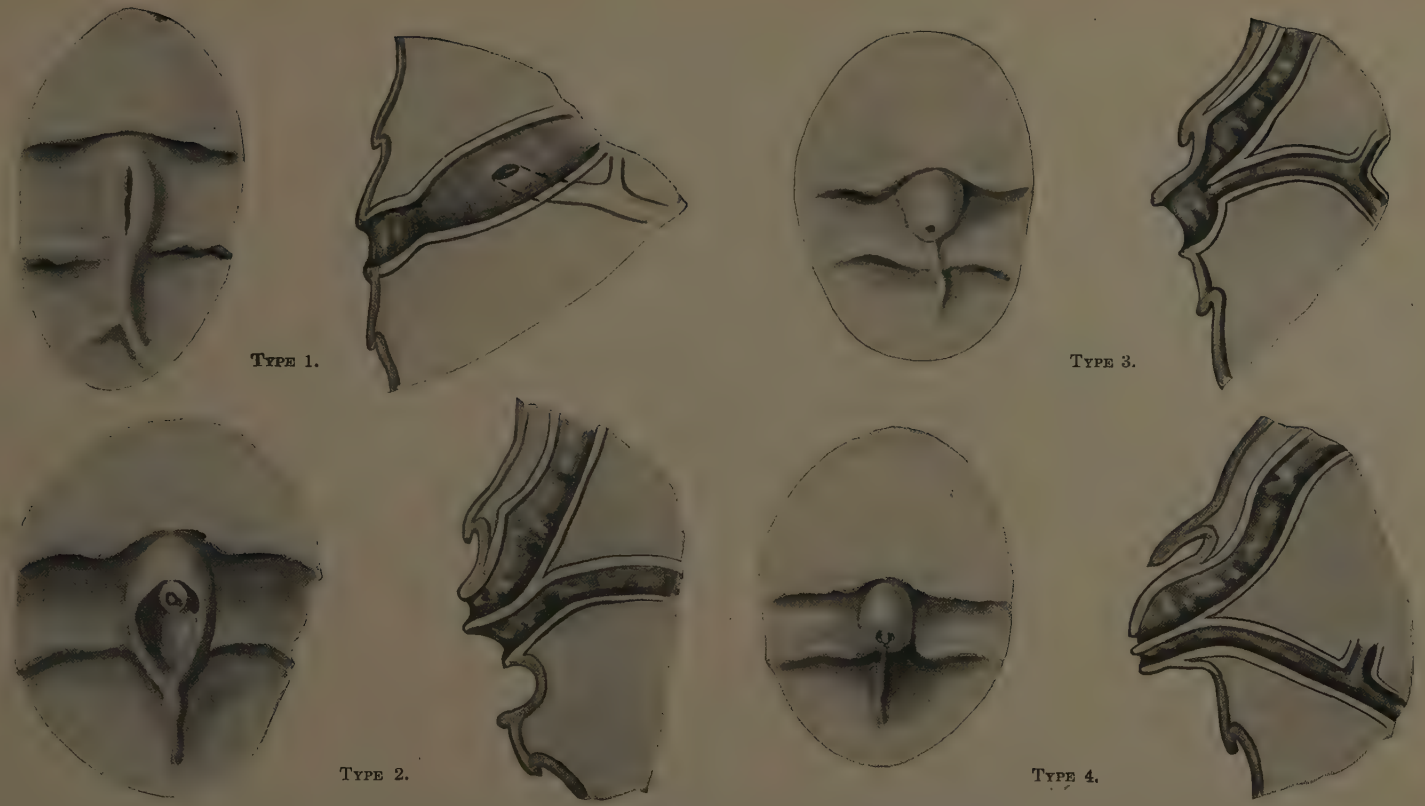

Fig. 533.—The Four Types of the Relationship of the Duct of Wirsung and the Common Bile Ducts. According to Nattan-Larrier and Letulle; seen from the duodenal surface in section.

on the summit of a papilla (type 2). Finally, the duct of Wirsung may open directly into the intestine alongside the bile duct, either into a trough or at the extremity of a papilla (types 3 and 4).

The pancreas also possesses a second duct, the duct of Santorini, which is usually quite subsidiary to the duct of Wirsung; it is a short channel and may open separately into the duodenum above the bile papilla, or it may drain a portion of the head of the gland into the duct of Wirsung, or again it may open by one extremity into the main pancreatic duct and into the duodenum by the other, sometimes forming the chief means of outlet for the pancreatic juice.

Abnormalities of the pancreas are not very infrequent. The gland may be divided almost into two parts by a deep cleft, bridged over only by the duct of Wirsung surrounded by a thin layer of pancreatic tissue. The tail of the gland may be bifid, each portion having its own duct. Various anomalies of the duct may be found, the chief of which are concerned with the termination of the duct of Wirsung in the duodenum. The most important anomalies are those in which an accessory pancreas is found or a ring of pancreatic tissue surrounds the duodenum.

Accessory Pancreas.—In a certain, probably not very small, proportion of cases an aberrant pancreas is found, always with a duct opening into the alimentary canal.[3] The accessory gland may lie in the wall of the stomach, duodenum, jejunum, or ileum to within a few feet of the ileocecal valve. In many cases the gland tissue is found imbedded in the wall of a diverticulum from the intestine; it may lie in the submucous or in the muscular layer of the bowel. Nodules of pancreatic tissue are also found in the papilla minor of Santorini. In one case an accessory pancreas has been found in the wall of a congenital umbilical fistula.

Annular Pancreas.—Several cases have been met with in which a complete ring of the pancreas surrounded the duodenum.[4] As a rule it is the upper part of the second portion of the duodenum which is encircled.

That portion of the head of the pancreas which lies behind the mesenteric vessels may be detached from the remainder of the gland; it is then known as the lesser pancreas.

The pancreas is an acinotubular gland. Its ducts are lined by columnar epithelium, the cells being longer in the larger ducts and shorter and thicker in the smaller ducts. The intercalary ducts, those connected with the alveoli, are lined by flattened cells. The secreting cells are quite characteristic in appearance. Imbedded in the gland are certain masses or groups of cells which lie in the interalveolar tissue, differing greatly from the ordinary secretory cells. These groups are made up of small irregularly polygonal cells with a round nucleus and a homogeneous refractive cell body. These structures are now universally known as the "*islands of Langerhans.*"[5] As was first shown by Merkel and Bonnet, they are the homologue of the primitive pancreas of the cyclostomata.

Functions.—The pancreas, like many other glands, has an internal and an external secretion. The internal secretion is the product of the islands of Langerhans, and controls the assimilation of sugars. The islands of Langerhans have no connection with the secreting cells or with the ducts of the pancreas, and any pathologic change in them produces, therefore, no alteration in the external secretion. The external secretion poured into the second part of the duodenum at the diverticulum of Vater is the most active and the most important of all the digestive juices. Diseases of the pancreas may affect the

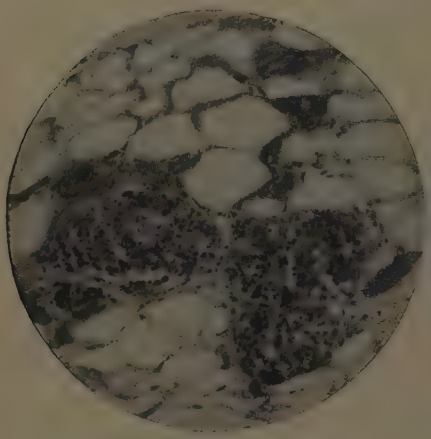

FIG. 534.—TWO NORMAL ISLANDS OF LANGERHANS IN A MASS OF FATTY TISSUE. (A. E. Finney.)

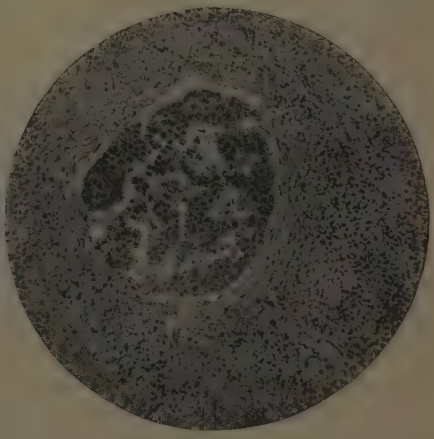

FIG. 535.—NORMAL ISLAND OF LANGERHANS SURROUNDED BY NEW GROWTH. (A. E. Finney.)

islands of Langerhans only, thereby interfering with the internal secretion; or the parenchyma of the gland, thereby interfering with the external secretion, or rarely and in advanced stages only, the whole gland may be involved and both secretions may be lessened or abolished.

THE DIAGNOSIS OF PANCREATIC DISEASE.

There are certain signs and symptoms present in cases of lesion of the pancreas which are peculiar to, or strongly suggestive of, the affections of this gland. These are:

1. Hemorrhage.
2. Fat necrosis.
3. Altered character of the stools.
4. Alteration in the constituents of the urine.

1. **Hemorrhage.**—The occurrence of hemorrhage into the substance of the pancreas has long been recognized, but its importance was not known until Fitz[6] described "acute hemorrhagic pancreatitis" in 1889. Hemorrhage may occur spontaneously into the substance of the pancreas, where its remains may be discovered by chance at an autopsy, months or years later. So excessive may this effusion be that the

patient may die, and no other cause for death be found than this. In such cases there is an absence of any disease or infection in the gland; the process is an aseptic one. For such conditions the term "pancreatic apoplexy" is appropriate. The symptoms, collapse, dyspnea, and feeble, rapidly failing pulse come without warning and may prove fatal suddenly or in a few hours.

In certain cases of acute inflammation of the pancreas, hemorrhage is at times of such severity that all other manifestations of disease are obliterated; the gland is then large, phlegmonous, and sodden with blood. This is the "acute hemorrhagic pancreatitis" of Fitz, to be described later.

But further than this, there is, as Mayo Robson was the first to show, a tendency in pancreatic disease to general hemorrhages, within the abdomen more especially, but at times elsewhere. In carcinoma of the head of the pancreas, for example, large and even fatal hemorrhages in the subperitoneal tissue, at some distance from the pancreas, may occur, and may cause death. I have seen many cases of petechial hemorrhages, and a few of extensive bruising of the skin, and in one instance repeated and severe bleeding from the bowel. The cause of this hemorrhagic tendency is said by Robson and Cammidge to be this: that in all cases of pancreatic disease there is an abundant excretion of lime salts in the urine. These salts are derived from the blood, which is thereby impoverished. As A. E. Wright has demonstrated, this in its turn causes a diminished power of coagulation in the blood and a tendency to hemorrhages.

2. **Fat Necrosis.**—Balser,[7] in 1882, called attention to the condition of fat necrosis, though earlier observations thereon had been made by Ponfick and Klob. In association with certain diseases of the pancreas the fat in the neighborhood of the gland, or, less frequently, that at some distance away, is seen to be studded with round, white, ivory-colored or sulphur-yellow specks or splashes, which on microscopic examination are seen to consist of altered fat-cells. These spots may be close together or scattered; they are often surrounded by a reddish rim, and the whole appearance contrasts very remarkably with that of the normal fat in which they lie.

The investigations as to the cause of fat necrosis have been intricate and prolonged. Fitz, in his memorable paper published in 1889, first suggested that it was the result of a lesion of the pancreas; but it is to the work of Langerhans[8] that we are indebted for the full, though not yet complete, knowledge which we now possess with regard to it. Langerhans showed that the changes which occur in the fat cells are due to the splitting up of the fatty molecule into its fatty acid and glycerin. "Fatty acids are deposited as needle-like crystals within the cell, which has lost its nucleus and is evidently necrotic, while the soluble glycerin is absorbed. Very soon the fatty acids unite with calcium to form calcium salts, and within the cell outline which is still preserved are irregular, often globular masses, in which the presence of lime salts may be demonstrated by microchemical reactions. A pro-

liferation of the fixed tissue cells occurs at the periphery of the necrotic area" (Opie).

Experimental investigations inaugurated by Langerhans have shown conclusively that the escape of the pancreatic juice from the gland into the surrounding fat is competent, through the agency of its fat-splitting ferment, to cause fat necrosis. If the pancreatic duct be ligatured, the fat in the part of the gland distal to the block shows this characteristic change; the same result occurs if the gland be lacerated in such a manner as to permit the escape of the juice. In the necrotic areas so produced Simon Flexner has demonstrated the existence of a fat-splitting ferment. In several of the recorded cases the fat lying at some distance from the gland shows clear evidence of this process of saponification; this is due in all probability to the conveyance of the ferment to the affected area through the lymphatics.

Opie, who has investigated the matter in man and by experiment upon animals, comes to the following conclusions:

a. The condition essential to the production of focal fat necrosis is the penetration of the fat-splitting ferment of the pancreas into the living adipose tissue.

b. By causing the entire secretion of the pancreas in cats to penetrate into the tissue surrounding the organ, wide diffusion takes place and necrosis results, not only in the abdominal fat, but in that of the pericardium and subcutaneous tissue as well, thus reproducing the widespread distribution of the lesion occasionally seen in man and in the lower animals.

c. Lesions of the pancreas associated with focal fat necrosis are such as to permit the diffusion of the pancreatic ferment into the surrounding tissue.

In some rare instances fat necrosis has been found without evident lesion of the pancreas. Such cases were described by Flexner and Fraenkel, but in both there were stones in the ampulla of Vater or in the common duct, and some injury to the pancreas was probable. There are, however, a few instances in which fat necrosis has been found when the most minute examination has failed to reveal any pancreatic disease. In such cases a fat-splitting ferment may possibly have escaped from the pancreas, which shows no evidence of disease; or a ferment may have been produced apart altogether from the pancreas, as the result, it may be, of the activity of micro-organisms. The nature of such cases requires further investigation.

3. **Altered Character of the Stools.**—The most noticeable character of the stools in pancreatic disease is their bulk. The motions passed are often enormous in quantity—the result of inadequate digestion of the food. The bulky stools are soft and light-colored. The absence of pigment in the motions in cases of pancreatic obstruction was first described by Claude Bernard,[9] and later by Walker,[10] of Peterborough. The normal coloration of the feces is not due to bile-pigments, which are all absorbable, but to a pigment which is insoluble and which results from the action of the pancreatic juice upon some of the coloring

matters of the bile. The absence either of the bile or the pancreatic juice results, therefore, in the passage of unpigmented feces. But it is not mere absence of normal color that characterizes the stools; there is a distinct whiteness, which is due to the presence in large quantities of undigested fat. *Steatorrhœa*, or the passage of fat in the stools, was first described in association with disease of the pancreas by Kuntzmann, in 1820, and by Bright, in 1833. Fles, in 1864, recorded the case of a diabetic who, after eating fat of bacon and meat, passed so large a quantity of undigested fat that it could be recovered from the feces by the ounce. The administration of a pancreatic emulsion caused the fat to disappear; on discontinuing the emulsion the fatty stools were seen again. The significance of fatty stools and the relative value of this symptom in association with the other to be described may be summarized as follows: Fat is found in the stools in three forms; as fat droplets, in the form of crystals of fatty acids, and as soap. The digestion of fats is the work of the pancreatic juice, the bile, the intestinal juices, and of the intestinal bacteria. The capacity for the digestion and absorption of fats is limited; if, therefore, fat is taken in excess, or if any of the fore-named aids to its digestion are lacking, it may be found in excess in the feces. If jaundice is absent and all the bile is passing into the intestine, an excess of fat in the stools is suggestive of pancreatic disease. If azotorrhea and steatorrhea are simultaneously present, the evidence in favor of pancreatic disease is strong; if also the pancreatic reaction is present, the evidence is conclusive. A further characteristic of the stools in pancreatic disease is azotorrhea or the faulty digestion of albuminous foods, more especially of muscular fibers. The majority of individuals in good health eat more meat than is necessary, and a certain amount of undigested muscular fiber is, therefore, almost constantly present in the stools. But in the absence or diminution of the pancreatic juice large quantities or almost the whole of the ingested meat passes through the bowel unaltered. Azotorrhea with steatorrhea suggests pancreatic disease; the two associated with glycosuria make the suspicion stronger. If the two are found at the same time as the "pancreatic reaction" in the urine, the suspicion becomes almost a certainty.

4. **Alterations in the Constituents of the Urine.**—*a.* **Glycosuria.**—In 1788 Cawley first noticed the association of glycosuria and pancreatic disease, but it was Lancereaux, in 1877, who first emphasized the dependence of diabetes upon lesions of the gland. The experimental work of von Mering and Minkowski has shown that total extirpation of the pancreas produces all the symptoms of diabetes, glycosuria, polyuria, polyphagia, and wasting. It is, however, to Opie that we are indebted for the final demonstration of the relationship between glycosuria and lesions of the pancreas. It is now known that the internal secretion of the pancreas has a controlling influence upon the carbohydrate metabolism, that this secretion is produced by the islands of Langerhans, and that in pancreatic diabetes it is these islands which show evidence of degeneration. As Opie[11] says, "where diabetes

is the result of pancreatic disease, injury to the islands of Langerhans is responsible for the disturbance of carbohydrate metabolism, since that influence which the normal pancreas exerts upon the assimilation of sugar is a function of these structures."

b. **Alimentary Glycosuria.**—von Mering and Minkowski[12] show that if to an animal, whose pancreas had been partly removed, sugar was given in moderate quantities, temporary glycosuria resulted. If, in man, the pancreas be so damaged by disease that its secretion is reduced in quantity or in activity, the administration of sugar by the mouth results in glycosuria, the severity of which is a measure of the extent of the lesion in the gland.

c. Other alterations in the urine detected by Cammidge's reaction. The importance of this subject is such that in order to have an authoritative description of "Cammidge's reaction" I have obtained from its author the following brief description of his method of examination of the urine and feces:

The Technic of the Examination of the Urine and Feces in Suspected Cases of Disease of the Pancreas.—In the method of performing the "pancreatic" reaction described in my Arris and Gale lecture at the Royal College of Surgeons in 1904 (Lancet, March 19, 1904), two specimens of urine, one of which had been treated with mercuric chlorid, were boiled with hydrochloric acid for ten minutes, and after the excess of acid had been neutralized with lead carbonate, were examined by the phenylhydrazin test. The presence of active inflammatory mischief in the pancreas was then indicated by a difference in the amount of deposit yielded by the two samples, when they were allowed to cool undisturbed. This method had the great disadvantage of being a comparative test, not capable of accurate measurement, and, therefore, dependent to a certain extent for its interpretation upon the experience of the observer. In addition, errors of technic, unless carefully guarded against, were liable to occur. By an improved method, which I described in a paper read before the Royal Medical and Chirurgical Society in March, 1906 (Brit. Med. Journ., May 19, 1906), the first of these difficulties has been overcome, but the manipulation is slightly more complicated, and still requires a reasonable amount of care, particularly in the details of the experiment. The test is essentially the same as the original "A" reaction, but differs in that the glycuronic acid set free in the process of hydrolysis is removed from the acid filtrate with tribasic lead acetate previous to applying the phenylhydrazin test.

The method of examination I now employ is conducted as follows: A specimen of the 24 hours' urine, or of the mixed evening and morning excretions, is filtered several times through the same filter paper, and tested for albumen, sugar, bile, urobilin, and indican. The reaction to litmus is taken, and a quantitative estimation of the chlorids, phosphates, and urea is made. The centrifugalized deposit from a specimen of the urine is also examined microscopically for calcium oxalate crystals. If the urine is found to be acid in reaction and is free from albumen and sugar, 2 cc. of strong hydrochloric acid (sp. gr., 1.16) are mixed with 40 cc. of the clear filtrate, and the mixture boiled on a sand bath in a small flask having a long-stemmed funnel in the neck to act as a condenser. After boiling for ten minutes the flask is well cooled in a stream of water and the contents made up to 40 cc. with cold distilled water. The excess of acid is next neutralized by slowly adding 8 grams of lead carbonate. After standing for a few minutes to allow of the completion of the reaction the flask is again cooled in running water and the contents filtered through a well-moistened close-grained filter paper until a perfectly clear

filtrate is secured. The filtrate is then well shaken with 8 grams of powdered tribasic lead acetate, and the resulting precipitate removed by filtration, a clear filtrate being obtained by repeating the filtration several times if necessary. Since the large amount of lead now in solution would interfere with the subsequent steps of the experiment, it is removed, either with a stream of sulphuretted hydrogen or, what I have found to be equally satisfactory and less disagreeable, by precipitating the lead as a sulphate. For this purpose the clear filtrate is well shaken with 4 grams of finely powdered sodium sulphate, the mixture just raised to the boiling point, then cooled to as low a temperature as possible in a stream of cold water, and the white precipitate removed by careful filtration. Ten cc. of the clear transparent filtrate are then made up to 17 cc. with distilled water, and added to 0.8 grams of phenylhydrazin hydrochlorate, 2 grams of sodium acetate, and 1 cc. of 50 per cent. acetic acid, contained in a small flask fitted with a funnel condenser. The mixture is boiled on a sand bath for 10 minutes and then filtered hot, through

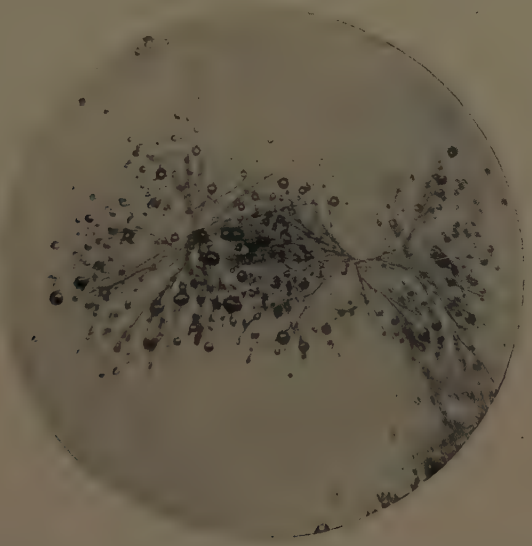

FIG. 536.—CRYSTALS OBTAINED FROM THE URINE IN A CASE OF PANCREATITIS IN WHICH THERE WAS A GALL-STONE IN THE PANCREATIC PORTION OF THE COMMON DUCT (from a photo by P. J. Cammidge).

a small filter paper moistened with hot water, into a test-tube provided with a 15 cc. mark. Should the filtrate fail to reach the mark, it is made up to 15 cc. with hot distilled water. In well-marked cases of pancreatic inflammation a light yellow flocculent precipitate should form in a few hours, but in cases where the inflammatory process is not so extensive, and is less acute, the preparation may need to be left over night. The precipitate may then consist of a few small flocculi that are only seen on careful examination. Under the microscope the precipitate is seen to consist of long, light yellow, flexible hair-like crystals arranged in sheaves which, on being irrigated with 33 per cent. sulphuric acid melt away and disappear in ten to fifteen seconds after the acid first touches them. In about 75 per cent. of cases of cancer of the pancreas no reaction is obtained, but in the remainder a more or less marked crystalline deposit is seen, probably due to the inflammatory changes produced in the gland by the extension of the growth To exclude traces of sugar undetected by the preliminary reduction tests a control experiment is carried out

by treating 40 cc. of the filtered urine in the same way as in the test described, save that it is not boiled with the hydrochloric acid. The urine employed for the examination should be fresh and not have undergone fermentative changes. If alkaline in reaction, it must be made acid with hydrochloric acid before the test is commenced. Any glucose that may be present can be removed by fermentation after the urine has been boiled with hydrochloric acid and the excess neutralized.

This improved method of investigation has been found to give indications of very considerable value in a large number of cases, especially when the results are considered in conjunction with the clinical symptoms and evidence to be obtained by other methods of investigation. Like most clinical tests, no doubt it has its limitations and it is not altogether independent of the skill of the observer. In the latter respect, however, it does not differ from most methods employed in clinical pathology, for even such a commonly employed reaction as Fehling's test is apt to give misleading results, at times, in inexperienced hands.

In many cases of suspected pancreatic disease, and particularly in those where the diagnosis rests between cancer of the pancreas and obstruction of the common duct by gall-stones, I have found that an examination of the feces, by a method I described at the Leicester meeting of the British Medical Association (Brit. Med. Journ., Oct. 28, 1905), is a useful check upon the results obtained by the analysis of the urine. My procedure is, after noticing the naked-eye characters, to make a careful microscopic investigation of specimens taken from various parts of the sample for fat globules, fat crystals, undigested muscle fibers, inorganic crystals, etc.; then to take the reaction to litmus of a portion selected from the center of the mass, and subsequently to estimate the percentage of "total fat," "neutral fat," and "fatty acid" in a specimen dried to a constant weight on the water bath. Finally, an examination for stercobilin is made. For the estimation of the fats I have adopted a method which, while much more rapid than the Soxhlet process, gives results that are satisfactory for clinical work. Two clean, dry Schmidt-Stokes milk-tubes, labeled A and B, and provided with a 10 cc. mark are taken, and into the lower bulb of each is introduced an accurately weighed quantity (about half a gram) of the finely powdered dry feces. The residue on the watch-glass is used for weighing, and the sides of the short-necked funnels with which the powder is introduced into the tubes are washed down with a fine jet from a wash-bottle, which for the "A" tube contains hydrochloric acid (1.3), and for the "B" tube, plain water. The sides of the tube are also washed down until the whole of the sample is collected in the lower bulb and the 10 cc. mark is reached. The "A" tube is then heated in boiling water for 20 minutes, occasionally rotating it so as to mix well the contents. After cooling, both tubes are filled to the 50 cc. mark with ether, securely corked, and inverted forty times so that the whole of the solid material runs through the ether each time. Each tube is then rotated between the hands, in order that the solid residue may be collected in the lower bulb, but considerable care is necessary in carrying out this part of the operation in some cases, or a perfectly clear supernatant layer of ether, free from solid, is not secured. With a pipet exactly 20 cc. of the clear ethereal extract are drawn off from each tube and delivered into 2 CO_2 flasks of known weight, the amount of ether left in the tubes being at the same time noted. The ether in the flasks in then evaporated, the residue dried, and the flasks again weighed. From the amount of extract yielded by 20 cc. of ether, and the quantity of ether left in the tubes, the total amount yielded by the weight of feces employed can be calculated, and from this the percentage in the dried stool can be determined. For convenience of reference I am in the habit of referring to the yield from the "A" tube as "total fat," that from the "B" tube as "neutral fat," and the difference between the two as "fatty acid." The solid residue in the "B" tube can be used for detecting stercobilin. For this purpose it is filtered

off, extracted with acid alcohol, the extract neutralized with ammonia, and mixed with an equal volume of 10 per cent. zinc acetate in alcohol. The precipitate that forms is removed by filtration and the clear filtrate examined against a black background with a lens for the green fluorescence that indicates the presence of stercobilin. The intensity of the color varies with the amount of pigment, so that by always using approximately the same proportion of feces and of the reagents any marked variation from the normal can be detected.

When there is disease of the pancreas, the feces are generally acid in reaction, while in cases of simple biliary obstruction, not associated with a pancreatic lesion, the reaction is usually alkaline. In practically all cases of simple pancreatitis stercobilin can be found in the feces, although in some instances where the pancreatic inflammation is associated with recent obstruction of the common duct by an impacted gall-stone only traces can be detected. Even traces of stercobilin are uncommon in cancer of the head of the pancreas, at least in the stage at which they generally come under observation, so that this is a useful sign in suspected cancer cases where the pancreatic reaction in the urine is positive. The discovery of numerous undigested muscular fibers microscopically is suggestive of malignant disease, although large numbers may also be met with in cases of advanced inflammation of the gland. Microscopically, too, crowds of fat globules and fat crystals are always to be found in cases of serious pancreatic disease.

The quantitative estimation of the "total fat" gives results that are always above the normal in cancer of the pancreas and are generally excessive in inflammatory lesions of the gland. The relation between the "neutral fat" and "fatty acid," which are normally present in about equal amounts, is almost invariably much disturbed in malignant disease and generally shows a marked variation from the normal in all but slight inflammatory conditions, the "neutral fat" being in excess. In simple biliary obstruction, not associated with disease of the pancreas, although the percentage of "total fat" is often in excess and the relation of the "neutral fat" to the "fatty acid" is disturbed, the tendency is for the latter to preponderate.

PANCREATITIS.

Though it has been known for centuries that the pancreas was liable to the same inflammatory diseases that affected other organs, it is only within the last twenty years that the frequency and the clinical importance of the disease have come to be recognized.

Inflammation of the pancreas may affect the ducts chiefly or the substance of the gland proper. Of the two forms, *catarrhal* and *parenchymatous* inflammation, the latter is the more frequent and the most important.

Catarrhal Pancreatitis.—Catarrhal inflammation of the ducts of the pancreas depends for its existence upon an infection spreading upward along the canal of Wirsung from a focus within the duodenum, within the ampulla of Vater, or in the lower part of the common bile duct. As has been already mentioned, the end of the pancreatic duct varies in different cases in so far as its relationship to the bile duct is concerned. In the majority of cases an infection of the common duct is capable of spreading by direct extension to the duct of Wirsung, and should this happen, an already grave condition of affairs becomes much more serious. If a gall-stone be impacted in the lower part of the bile duct, an infection spreads both upward and downward from it;

as it descends it reaches the ampulla and thence extends along the pancreatic duct. If the stone be impacted in the ampulla, the infected bile descending the common duct may be retrojected along the canal of Wirsung, and a catarrhal or an acute hemorrhagic inflammation may be aroused. Similarly, a malignant growth in the ampulla or near it, becoming infected, may set up a spreading septic inflammation which involves the ducts of the liver and the pancreas.

The infection which causes the onset of the catarrh of the pancreas may spread from the duodenum, where it has been set up by ulceration or by a low-grade inflammation in the stomach or duodenum due to the imbibition of irritant foods. Catarrh of the pancreas, recognized so seldom, is not improbably a frequent concomitant of infection of the common bile duct. The impaction of a gall-stone in the common duct is not an infrequent occurrence, and when the anatomic conditions are studied, the extreme probability of infection of the pancreas is realized. The catarrh, of course, is relieved by the removal of the infecting agent in the very great majority of cases, but most surgeons whose experience in gall-stone work is extensive have met with cases in which chronic inflammation of the pancreas has remained. This, as will be seen later, is a serious condition; in its more advanced stages it is irremediable. A clearer recognition, then, of the intimate association of catarrh of the pancreas with inflammation in the common bile duct is desirable.

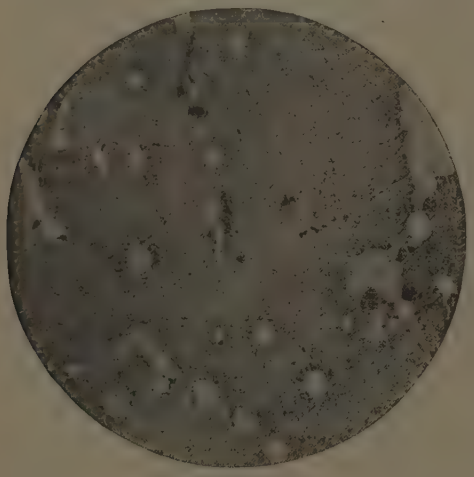

FIG. 537.—EARLY INTERSTITIAL PANCREATITIS WITH CATARRH OF DUCTS AND DILATATION OF VESSELS (from a photo by P. J. Cammidge).

In rare cases the catarrh of the duct may go on to suppuration; just as in the bile duct simple catarrh may lead up to suppurative cholangitis. In either case the onset of suppuration is an extremely serious matter, and probably the majority of cases in which acute suppurative catarrh is present prove fatal, the symptoms being of a septicemic or pyemic character. If the infection is of a less severe grade, a localized suppuration (abscess) may result.

Catarrhal pancreatitis or inflammation of the pancreatic ducts may, therefore, be of every grade of severity, from the slightest transient to the most acute suppurative inflammation. The cause in all cases is similar, an ascending infection from a septic focus; the varying character of the initial infection determines the severity of the consecutive inflammation.

Parenchymatous Pancreatitis.—The following classification is given by Mayo Robson:[13]

Pancreatitis.

1. *Acute*
   - *a. Hemorrhagic*
     - *a.* Ultra-acute, in which the hemorrhage precedes the inflammation, the bleeding being profuse and both within and outside the gland.
     - *b.* Acute, in which inflammation precedes the hemorrhage, which is less profuse and is distributed in patches throughout the gland.
   - *b. Gangrenous.*
   - *c. Suppurative* (diffuse).
2. *Subacute* — Abscess of the pancreas.
3. *Chronic*
   - *a.* Interstitial
     - *a.* Interlobular.
     - *b.* Interacinar.
   - *b.* Cirrhosis of the pancreas.

Acute Pancreatitis.—Before discussing the details of acute pancreatitis in its various forms some reference is necessary to the varying circumstances of hemorrhage in and around this gland. It is of course well recognized that slight degrees of hemorrhage occur into the substance of the pancreas in all stages of an inflammatory process within the gland; and even apart altogether from any demonstrable results of inflammation. As to what the exact connection may be between hemorrhage and inflammation, a host of writers have borne testimony. There are those who hold that hemorrhage occurs altogether apart from inflammation, not caused by it, not causing it; that such hemorrhage may be fatal; and that at a careful post-mortem examination there may be not the smallest trace of an inflammatory process. This condition is known as "pancreatic apoplexy." There are others who hold that an acute inflammation of the gland is the primary factor and that hemorrhage, slight or of great severity, is secondary. There are again others who hold that in cases of acute hemorrhagic pancreatitis, the hemorrhage occurs first and is followed speedily by an acute inflammatory outbreak in the injured gland, which by reason of the connection of its duct with the intestine is within easy access of an infected mucous membrane. Finally, Mayo Robson in the classification given above discriminates between the two latter forms. He considers that there are two varieties which may be clinically differentiated, the ultra-acute cases with a violent and sudden onset, accompanied by collapse and ending fatally with extreme rapidity, being chiefly those where the hemorrhage precedes the inflammation, while the less though still acute cases where the onset is more gradual, where the symptoms are not ushered in by collapse, and where resolution and relapse are liable to occur, being those in which the inflammation precedes the hemorrhage. Mikulicz considered that the only point of difference between pancreatic apoplexy and acute hemorrhagic pancreatitis was that the former was a sterile, the latter an infected process. The whole subject is in need of fuller investigation.

Etiology.—The work of Opie, Simon Flexner,[14] and others has given us a clearer understanding with regard to the causation of acute pan-

creatitis. They have made it certain that in a great majority of the cases the process is an infective one, and that the irritant extends upward from the termination of the duct. Flexner in ten experiments upon dogs injected HCl of $\frac{1}{2}$ to 2 per cent. strength, in quantities of 3 to 8 cc., into the pancreatic duct. In 6 instances acute hemorrhagic inflammation of the gland followed, accompanied by fat necrosis. Other irritants were used in later experiments, nitric acid, artificial gastric juice, suspensions of bacteria, and alkalies, with similar results; acute inflammation with hemorrhage followed. Opie in 1 case of acute pancreatitis discovered a small gall-stone impacted in the ampulla, the orifice of which it blocked, but the lumen of which it did not fully occupy. The diverticulum measured 10 mm. in diameter, the calculus 3 mm. The result was that the common bile duct and the pancreatic duct were converted into a single channel and the bile, secreted under greater pressure, forced its way upward into the canal of Wirsung, the walls of which were stained bright green by it. Opie,[15] thereupon undertook a series of experiments which proved that the injection of bile into the pancreatic duct was a certain cause of acute pancreatitis. The anatomic peculiarities, permitting a small gall-stone to block the diverticular orifice and to divert the bile in the way Opie described, exist only in about 30 per cent. of individuals. In an investigation into recorded cases Opie showed that the connection between gall-stone obstruction of the common duct termination and acute pancreatitis was demonstrable in many cases; many cases subsequently recorded support his views.

Other infections are now recognized as capable of setting up inflammation in the pancreas—typhoid fever for example—the first case of typhoid pancreatitis being recorded by myself; mumps, as shown by Simonin[16] and others; and influenza. Gastric or duodenal ulcer, by extension of the inflammation, may affect the gland. Vascular diseases, syphilis, and alcohol are also named as causative influences. An unusually large proportion of cases of acute pancreatitis have occurred in pregnant women at about the third month.

Symptoms.—A patient, often in the best of health, robust, and inclined to stoutness, is suddenly seized with acute intolerable pain in the upper part of the abdomen. The agony may be so great that collapse or fainting occurs, to be followed by vomiting. The pulse is rapid and of poor quality, the respirations are shallow and hurried; the patient looks drawn and ill. The character of the symptoms is such that perforation of the stomach, duodenum, or appendix may be suspected. In one case I saw, a diagnosis of hepatic colic had been made, in another of perforation of the stomach, in another of perforation of the duodenum. The abdomen, as a rule, is not rigid, nor is it tender except on deep pressure in the epigastrium; at first there is no distention, but within 12 to 24 hours there is generally a distinct fulness in the epigastrium and later a general intestinal distention may develop. In a few cases vomiting is persistent and almost uncontrollable; in these cases acute, high, intestinal obstruction may be suspected.

The vomitus consists at first of the contents of the stomach, then of bile-stained fluids, and finally of altered blood, "black vomit." In all the cases I have seen there has been a curious leaden color of the face and lips, and Halsted has also called attention to cyanosis of the face and of the abdominal wall. In all, the pulse-rate has risen steadily from the onset of symptoms, and in one case was the only sign to cause anxiety during the first 24 hours. The temperature is generally raised, but is apt to vary. In many cases there may be jaundice, which is generally slight. As a rule, a diagnosis can be made from the history of a sudden onset, and from the rapid development of signs of peritonitis in the upper part of the abdomen. The rule given by Fitz in his original paper is this: "Acute pancreatitis is to be suspected when a previously healthy person or a sufferer from occasional attacks of indigestion is suddenly seized with violent pain in the epigastrium, followed by vomiting and collapse, and in the course of twenty-four hours by a circumscribed epigastric swelling, tympanitic or resistant, with slight rise of temperature." In the more acute cases the downward progress of the patient is rapid, and death may occur in from twenty-four hours to five or six days. In the less acute cases the symptoms may improve after a couple of days, and an abscess may form in the pancreas. It is important to recognize that the two varieties given in the above classification are merely phases of the same condition. Acute pancreatitis may lead to gangrene or necrosis of the organ, or to suppuration, according as the infection is of greater or less intensity. Gangrene and diffuse suppuration, therefore, are to be considered only as terminal phases and not as special forms of acute inflammation of the gland.

Treatment.—Acute pancreatitis is probably fatal in the great majority of cases, unless surgical treatment is adopted early. The less acute cases may live until an abscess forms or until a dead part of the gland is cast off as a slough. But the more acute cases can only be cured by surgical treatment. What are the surgical indications? A consideration of the circumstances will convince one that the pancreas and its surroundings form a phlegmon, and that relief can only be given by affording free drainage of the inflammatory products. In many cases gall-stones in the duct, ampulla, or gall-bladder are present, and if time permits, these should be removed or the gall-bladder quickly drained; but the chief aim must be to secure drainage of the pancreatic territory sodden with inflammatory products.

The abdomen is opened above the umbilicus by an incision of good length, placed over the middle of the rectus. As soon as the fat is exposed, areas of necrosis are seen, and the diagnosis, if before in doubt, is now certain. When the peritoneum is opened, blood-stained fluid generally escapes and the pancreas, dark in color, greatly swollen, and engorged with blood, is readily exposed. It should be punctured lightly in several places or even incised freely; the fluid around is to be mopped up quickly, and free drainage afforded either through the original wound or through a posterior stab wound, in the left loin, or

in both directions. The gall-bladder and bile ducts are then rapidly inspected and such treatment of them adopted as seems proper. This, then, is the procedure: free exposure of the pancreas, its puncture or incision, the provision of free drainage, and the inspection, and if need be drainage, of the bile passages. This method of treatment was first successfully carried out by Ramsay. In a report of all cases published up to May 1903, von Mikulicz[17] gave details of 75 cases of operation for acute pancreatitis. Of 36 in which the pancreas was directly attacked by treatment, 25 recovered; in 41 where the pancreas was not touched, only 4 recovered, and in all these free drainage was provided.

Subacute Pancreatitis.—*Abscess of the Pancreas.*—The difference between subacute and acute pancreatitis is one of degree rather than of kind. No hard and fast line can be drawn between the two forms, yet a discrimination between them is of more than didactic interest, for the prognosis is vastly more favorable in the subacute form. The symptoms of subacute pancreatitis are those of the acute form in a slighter degree. There is a sudden onset of pain, acute, but not overwhelming, in the epigastrium; vomiting occurs, and perhaps faintness or slight collapse; but the patient is not profoundly ill. The pulse is neither so rapid nor so feeble as in the acute form. The epigastric region, though perhaps tender from the first and resistant, is not distended, at least not for some days. The patient, instead of hastening to his end, lingers, and may even improve after the third or fourth day, only to relapse at the eighth or ninth day when the abscess is beginning to enlarge. The temperature is often high in this stage, or even before, reaching at times 103° or 104° F., and a rigor or a succession of rigors may be witnessed. From the onset a loss of flesh and strength is manifest and may be striking. The time occupied before a diagnosis can be made varies much in different cases, according to the severity of the infection. As a rule, the history of the sudden onset, the hectic temperature, the rapid wasting, and the epigastric swelling and tenderness permit a diagnosis to be made.

When an abscess has formed it may, in its enlargement, become adherent to the stomach or intestine, and may empty through them; or it may reach the abdominal wall above or below the stomach, or the loin, or it may penetrate the diaphragm.

Treatment.—The subacute variety of pancreatitis is much more amenable to successful surgical treatment than is the acute form, though, as a rule, it is only after an abscess has formed, and the swelling caused by it has attracted attention, that the surgeon is asked for help. The abscess may be evacuated through the anterior abdominal wall or through incisions in the costovertebral angles, to left or to right; in 2 cases the transpleural route has been followed. The emptying of the abscess cavity and the protection of the peritoneal cavity from infection are secured in the usual manner.

Villar[18] has recently collected the records of 60 operations for pancreatic abscess: 33 patients recovered, 20 died, and in 7 the result was not stated. The after-results were ascertained in many cases, and were

not always satisfactory. A few patients died of diabetes, 1 of intestinal hemorrhage, 2 of phthisis, and a few recovered from the operation, only to die of exhaustion a few weeks or a few months later.

Chronic Pancreatitis.—Chronic inflammation of the pancreas is now recognized to be a far more common disease than was formerly supposed. The discovery of its clinical importance is due to the observations made during the operative treatment of gall-stone disease. Riedel, Körte, and especially Mayo Robson have contributed to our knowledge of this subject.

Interstitial inflammation of the gland is generally secondary; the irritants which cause it may arrive by way of the duct, through the arteries of supply, or by the lymphatics. The first of these is by far the most frequent; the infection which passes up the canal of Wirsung having its usual origin in the common bile duct. Bacteria or their products may reach the gland through the blood-stream. Arteriosclerosis is thought to be a cause of the disease. Syphilis undoubtedly, alcohol and tuberculosis possibly, are irritants causing inflammation. Growths or cysts of the pancreas, conditions causing obstruction of the canal of Wirsung, calculi, etc., inflammatory conditions of the stomach or duodenum, especially ulceration, and carcinoma of the stomach invading the gland are all causes of interstitial inflammation. The incidence of the interstitial inflammation is not always the same.

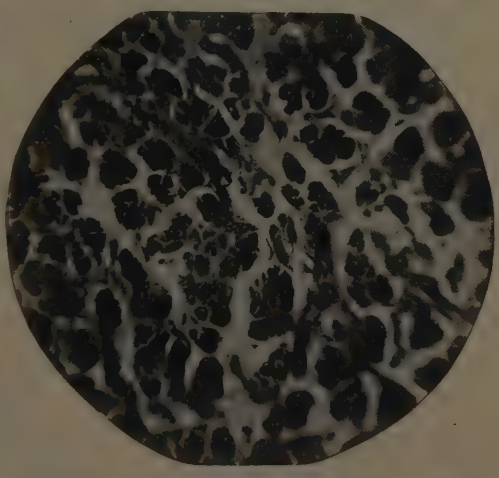

Fig. 538.—More Advanced Stage of Chronic Interstitial Pancreatitis.
Showing considerable increase of interstitial fibrous tissue (from a photo by P. J. Cammidge).

In accordance with Opie's description[19] two forms of inflammation are now recognized, interlobular and interacinar. In *interlobular* pancreatitis the inflammation which leads to a deposit of fibrous tissue attacks the strands which lie between the lobules of the gland, the intralobular tissue escaping entirely. In the *interacinar* form the fibrous tissue replaces the parenchyma of the gland and separates the individual acini.

In interlobular pancreatitis the deposit of fibrous tissue causes the lobulation of the gland, which is normally only slight, to become conspicuous; wide bands of cicatricial tissue cut up the organ irregularly. In interacinar pancreatitis the lobulation of the gland is not accentuated; the newly-formed fibrous tissue has a diffuse character, lies within the lobules themselves, and a network of thin, fibrous strands holds the acini in its meshes.

The importance of the distinction between these two forms of disease is due to their different behavior in respect of the islands of Langerhans. In interlobular pancreatitis which spreads from without the lobule inward the islands of Langerhans show no change until the very latest stage of all is reached, the stage in which almost the entire gland is reduced to a mass of fibrous tissue. In the interacinar form the growth of new tissue within the lobules implicates the islands of Langerhans from the first; indeed it is the tissue in closest proximity to them that is the most common seat of the disease. The commonest change exhibited by the islands is a hyaline degeneration. As is now well recognized, thanks to Opie, it is the involvement of the islands, their gradual destruction, and the consequent suppression of the internal secretion of the pancreas which they produce that is the cause of diabetes.

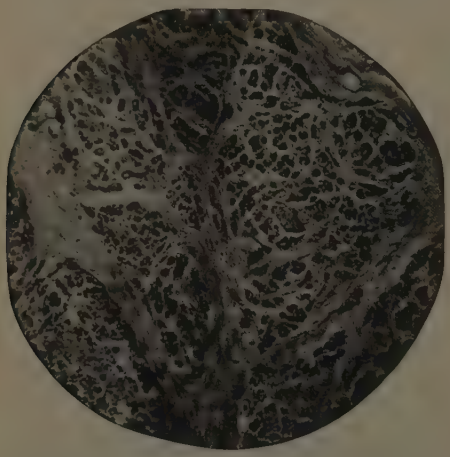

FIG. 539.—ADVANCED INTERSTITIAL PANCREATITIS.
Showing marked increase of intralobular connective tissue and some interalveolar fibrosis (from a photo by P. J. Cammidge).

Symptoms.—The symptoms of chronic pancreatitis vary much, according to the condition which has excited the inflammation. In the very great majority of cases it is an infection of the common bile duct, by the impaction of a stone therein which causes the inflammation of the pancreas. If a large stone be impacted in the second or third portions of the duct the infection may reach the gland either directly, spreading through the duct wall into the glandular substance of the pancreas which surrounds it, or indirectly, extending down to the diverticulum of Vater, thence up the canal of Wirsung, and so to the gland.

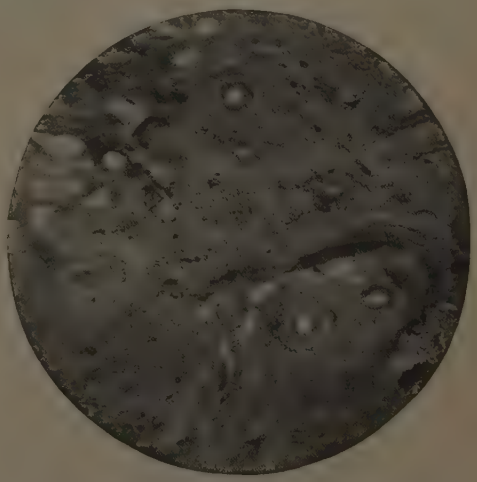

FIG. 540.—MARKED FIBROSIS OF PANCREAS.
From a case of diabetes with pancreatic calculi, almost complete replacement of glandular structure by fibrous tissue (from a photo by P. J. Cammidge).

In a severe form, that most commonly seen and most easily recognized, the head of the pancreas is so enlarged by chronic inflammation

that the common bile duct is compressed and jaundice results. When chronic pancreatitis is present at the same time as a stone in the common duct, the jaundice varies in the "ebb and flow" manner characteristic of intermittent calculous obstruction; but if the stone has passed the jaundice is steady, rarely varying perceptibly. Loss of flesh, often very rapid, pain in the epigastrium, azotorrhea, steatorrhea, and bulky, pale pultaceous motions are observed. The condition of the gall-bladder varies; as a general rule it is shrunken and fibrous, but in rare cases it may be dilated. If small and contracted the pancreatic inflammation is probably secondary to very old-standing gall-stone disease, which has set up a calculous cholecystitis, resulting in sclerosis. If dilated, then if gall-stones are, or have been, present, they have probably not been of long duration, or have not for one reason or another caused inflammation or ulceration in the gall-bladder. It is in the cases where the gall-bladder is dilated that an insuperable difficulty in diagnosis may arise, especially when the jaundice is unvarying. The co-existence of steady jaundice with distention of the gall-bladder suggests a diagnosis of malignant disease of the pancreas, in accordance with "Courvoisier's law." In such circumstances the only possible means of discriminating between malignant disease and chronic pancreatitis is in the application of "Cammidge's reaction" in the urine, and it is in these cases that Cammidge's test will find its most useful application. For my own part I place considerable reliance upon the color of the jaundice; in malignant disease the tinge is deeper and greener; in chronic pancreatitis it is never so deep, and inclines more to a pale golden yellow.

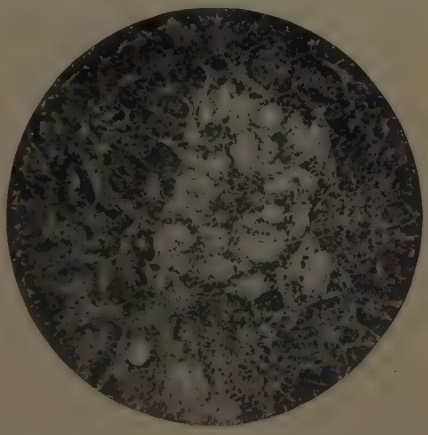

Fig. 541.—Hyaline Transformation of the Capillaries of an Island of Langerhans. (A. E. Finney.)

In early cases of chronic pancreatitis the symptoms are so slight that they are masked by the more important ones to which the gall-stone disease has given rise; but wasting, especially if rapid, epigastric fulness, pains radiating to the left side of the abdomen and chest, the characteristic stools, already described, and above all, the presence of Cammidge's reaction in the urine enable us to make a diagnosis. In the slighter cases, especially those in which the tail of the gland is solely or chiefly attacked, there are no means of achieving a diagnosis except that afforded by Cammidge's reaction.

Treatment.—As will be understood from the foregoing description, the treatment of chronic pancreatitis is often an offshoot, as it were, in the treatment of the varying circumstances of cholelithiasis. It is the

infection of the bile in the common duct which causes the pancreatitis. As Körte, and more especially Mayo Robson, have shown, the draining away of the bile until it has become aseptic is sufficient in most cases to cause the inflammation to subside. This may be effected in three ways, by cholecystotomy, choledochotomy or by cholecystenterostomy. Cholecystotomy and choledochotomy, followed by drainage, the tube being retained as long as possible, suffice in the majority of cases, but if the inflammation is of old-standing, the time during which drainage can be kept up after these operations is hardly sufficient and relapse is prone to follow the closure of the wound. In such cases cholecystenterostomy is the better operation, for drainage of bile is then permanent through the new opening. In practice the results are very satisfactory, though theoretically there is the risk of an ascending infection of the gall-bladder and hepatic duct from the bowel through the anastomosis. In the late cases, happily rare, treatment can only be palliative, for the fibrous deposit is so extensive that a gradual atrophy of all the cells of the pancreas and of the islands of Langerhans leads to death from inanition or from diabetes.

According to Mayo Robson, there are recorded 113 cases of operation for chronic pancreatitis with 8 deaths.

PANCREATIC CYSTS.

The study of cystic diseases of the pancreas is one beset with difficulties, for our knowledge of their pathology is slight, and clinical observations are comparatively few and imperfect. The following is a brief epitome of our present knowledge.

Pancreatic cysts are of the following varieties:[20]

1. Retention cysts.
2. Proliferation cysts { cystic adenoma. / cystic epithelioma.
3. Hydatid disease.
4. Congenital cystic disease.
5. Hemorrhagic cysts.
6. Pseudocysts.

From the pathologic point of view the inclusion of the last form is not permissible. As, however, the clinical distinction between these and the true forms is often impossible, it seems best to include a description of them.

1. **Retention Cysts.**—Virchow[21] described two forms of retention-cysts of the pancreas. In the one the whole duct is widened, and a "rosary-like" dilatation occurs; in the other the duct is blocked at its outlet, and becomes distended into a cyst which may reach the size of a fist, and may contain mucoid, hemorrhagic, or calcareous matter. In the case of the small cysts there can generally be little or no difficulty in determining their origin; in that of the larger cysts, such as the surgeon encounters, the differentiation may be difficult or impossible.

On the post-mortem table specimens have been recognized by

Virchow, Klebs, Gould, and many others. Virchow applied the term "ranula pancreatica" to a general distension of the whole duct. When numerous small engorgements of the minute ducts are present, Klebs suggested the name "Acne pancreatica."

2. **Proliferation cysts** may be either simple or malignant. The exact differentiation is not infrequently difficult, and is at times impossible from the pathologic point of view. In some cases one has to await the course of events after the removal of a cystic tumor before deciding as to the class in which to include it. Thus Fitz, of Boston, in relating a case, says: "The tumor, from its histologic appearances, is to be regarded as essentially a multilocular cystoma, but on the border line between a proliferating cystoma or cystadenoma and a cystomatous carcinoma, a distinction which the subsequent history of the patient may be expected to make clear."

3. **Hydatid cysts** of the pancreas are extremely rare. Masseron[22] was able to collect the records of only 5 cases, and these were first recognized on the post-mortem table. Graham, of Sydney, writes:

FIG. 542.—A PANCREAS THE DUCT OF WHICH IS WIDELY DILATED THROUGHOUT ITS ENTIRE LENGTH. The cause of the dilatation was not discovered. (Museum Royal Coll. Surg., Eng., No. 2823A.)

"The hydatid is sometimes found in the pancreas. I have observed it as a cyst about 3 inches in diameter replacing the head of the organ." Tricomi[23] states, without giving references, that 7 cases have been recorded.

4. **Congenital cystic disease,** similar to the congenital cystic disease of the liver and kidneys, has been observed on rare occasions. Pye-Smith recorded a case of cyst of the cerebellum, with numerous small cysts in the pancreas and kidneys; the patient was a man aged twenty-seven. Richardson[24] has recorded a cyst of the pancreas occurring in a child fourteen months old; and in 1 case, related by Shattuck, a tumor had been noticed since birth.

5. **Hemorrhagic Cysts.**—That bleeding may occur into the substance of the pancreas as the outcome of acute or chronic inflammation is well proved. As to the influence of these or other hemorrhages, traumatic or spontaneous, upon the building up of a cyst, no positive opinion can be expressed. Hagenbach distinguishes between hematoma, in which bleeding occurs into pre-existing cysts, and apoplectic cysts resulting from hemorrhage into softened, degenerate

gland-substance. In favor of the hemorrhagic origin of cysts are the writings of Kühnast, Schröder, and Friedreich.

6. **Pseudocysts.**—Körte has proposed the term "pseudocysts" for certain fluid tumors found in more or less close proximity to the pancreas, but not originating in the substance of the gland. The accurate distinction of a true pancreatic cyst from a pseudocyst is not always possible during life, for a cyst primarily peripancreatic may

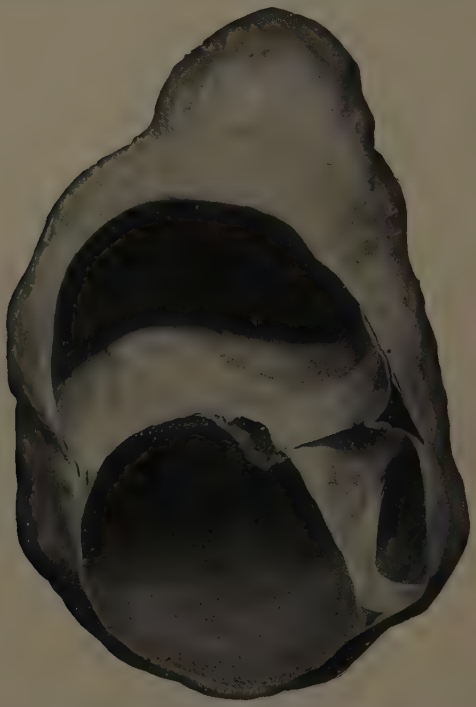

FIG. 543.—A THIN-WALLED CYST WHICH WAS REMOVED FROM THE PANCREAS.

It measures about six inches in its chief diameter and is multilocular; some of the larger compartments communicate with certain of the lesser by circular, sharply-defined apertures, due probably to the atrophy of the intervening partitions. The interior of many of the cavities is blood-stained from hemorrhage. During the operation much of the fluid was withdrawn by aspiration from two of the chief loculi; that from one was quite clear, that from the other blood-stained. The somewhat ropy, dull-brown mixture of the two was found to be strongly amylolytic when tested on starch solution. The patient, a middle-aged lady, had noticed the growth about seven months, having discovered it first from a slight pain felt on leaning the abdomen against some article of furniture. The swelling was thought to be a cystic kidney at the operation; the tail of the pancreas came out of the wound and had to be dissected off.

About an inch and a half or two inches from the end of the tail the connections of the cyst were most intricate, certain vessels occasioning much trouble in this situation (Museum Royal Coll. Surg., specimen No. 2834A). (J. D. Malcolm, Esq.)

originate in a trauma, which implicates the gland at the same time, so that the pancreatic juice may escape in small quantity into the pseudocyst and make its mimicry of a true cyst so complete that a distinction is impossible. I am indeed strongly inclined to believe that many cases of so-called pancreatic cysts, especially those of traumatic origin, are in reality peripancreatic or pseudocystic effusions into the lesser cavity of the peritoneum, localized extravasations of blood,

and so forth. In some recorded examples the origin of a cyst in the pancreas is purely hypothetical, and in these the tumor may be a "pseudocyst" of the pancreas or a true cyst of a neighboring organ, such as the suprarenal body.

The sequence of events in a case of "pseudocyst" in which a fluid accumulation occurs into the lesser sac is this: An injury is inflicted upon the epigastrium, and a laceration of the posterior layer of the lesser sac, and of the pancreas to which it adheres very intimately, results. Blood (and perhaps some pancreatic secretion) is poured through the rent into the lesser sac, and peritonitis therein results; the foramen of Winslow is sealed by adhesion and the lesser cavity of the peritoneum, now a closed sac, is distended with serous effusion, mixed with blood and pancreatic secretion. When the fluid is evacuated, the pancreas continues to pour its secretion into the lesser bag through the rent in its peritoneal investment. Cysts formed in this way are of course characterized by phenomenally rapid increase in size. A tumor from which several pints are evacuated may form in a few days.

It is to Jordan Lloyd[25] that we are indebted for the first clear recognition of the nature of these "pseudocysts." In a most valuable paper on the subject he summarizes his conclusions as follows:

(*a*) That contusion of the upper part of the abdomen may be followed by the development of a tumor in the epigastric, umbilical, and left hypochondriac regions.

(*b*) That such tumors may be due to fluid accumulations in the lesser peritoneal cavity.

(*c*) That when the contents of such tumors are found to have the property of rapidly converting starch into sugar we may assume that the pancreas has been injured.

(*d*) That many such tumors have been regarded as true "retention-cysts of the pancreas," and that this opinion has been formed upon insufficient evidence.

(*e*) That the diagnosis of distension of the lesser peritoneal cavity before operation can usually be made by the characteristic shape of the swelling.

(*f*) That early median abdominal incision and drainage is the safe and proper treatment.

A most interesting and unique case of true cyst and pseudocyst in the same patient is recorded by McPhedran.

Pathologic Anatomy.—Cysts of the pancreas are rather more frequent in men than in women. Of 121 cases collected by Körte, 60 were males, 56 females; in the remaining 5, no mention of sex is made.

The youngest patient affected was a child thirteen months old, whose case is recorded by Shattuck. Richardson has operated upon a child fourteen months old. Stieda's patient was a man of seventy-six.

The cystic tumor may be situated at any part of the gland, from the duodenal margin of the head to the tip of the tail. The body is more commonly affected than the head, and the tendency to implication seems, roughly, to increase as the tail is approached.

In 22 cases collected by Hagenbach[26] the cyst arose in the tail 10 times, 4 times in the head, once in the body, and in 7 the site is not indicated. Nimier[27] gives the following: 22 times in the tail, 6 times in the body, 4 times in the head, once in the head and the body, and in 1, the whole organ was implicated.

Cysts may be single or multiple, unilocular or multilocular. Two cysts may be simultaneously observed of almost equal size; or, after the healing of one cyst, a second may develop in a distant portion of the gland and necessitate further operation. One small cyst may be found with a large number of smaller ones packed in its walls. The cysts are generally smooth and rounded; they are elastic and rather tense. The inner surface of the cyst-wall is commonly smooth and lined throughout by cylindric epithelium; trabeculæ or incomplete septa may at times be present, and a "thimbling" of the surface may be seen. Intracystic polypoid masses are found in cases of proliferation cyst. In the great majority of recorded cases, blood in greater or less quantity has been observed.

Symptoms.—In the early stages, the symptoms are vague; they constitute the "cœliac neuralgia" of Friedrich. Pain, vomiting, epigastric distress, and fulness are the chief. Jaundice is present when the tumor presses upon the bile duct. Wasting, weakness, diarrhea, and salivation are all recorded. In all these there is nothing characteristic; it is only after the development of a tumor that the disease can be diagnosed.

The cystic tumor developing in the pancreas lies behind the posterior layer of peritoneum forming the lesser sac, and is covered, whatever direction it may take, by this layer of the serous membrane. The tumor is at first placed behind the stomach, but in its gradual enlargement it displaces the viscus. It may pass in one of three directions:

(*a*) In the great majority of cases the stomach is pushed upward and to the right, and the transverse colon is pushed downward, the cyst coming to the surface below the greater curvature of the stomach. In order to reach the cyst through the abdominal wall, the parietal peritoneum, the two layers of peritoneum forming the great omentum, and the posterior layer of peritoneum of the lesser sac all have to be divided. The amount of pressure and displacement to which the stomach and the transverse colon are subject depends entirely upon the bulk of the cyst. The stomach may be jammed tightly under the liver, and the transverse colon, as recorded by von Riedel, Salzer, Heinricius, and others, may be pushed down as low as the symphysis pubis.

(*b*) In certain cases the enlarging tumor may push its way forward above the upper border of the stomach. In order to reach the cyst in this position the following layers of peritoneum must be divided: the parietal, the two layers of the gastric hepatic omentum, and the posterior layer of the peritoneum of the lesser sac. The stomach is pushed downward and the liver forced upward and to the right. The most prominent part of the cyst presses against the anterior abdominal wall.

FIG. 544.—PRESENTING ABOVE THE STOMACH.

FIG. 545.—BEHIND STOMACH AND COLON.

FIG. 546.—COMING FORWARD BETWEEN STOMACH AND COLON.

FIG. 547.—BEHIND THE STOMACH.

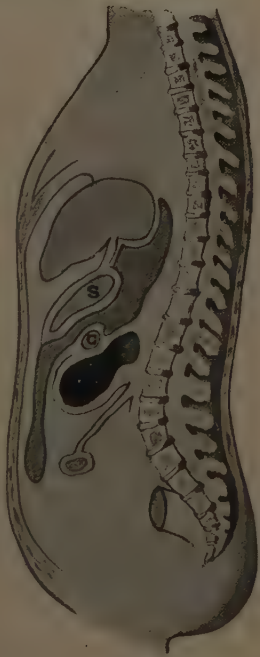

FIG. 548.—CYST BELOW THE TRANSVERSE COLON.

FIGS. 544–548.—A SERIES OF DIAGRAMS SHOWING POSITIONS TAKEN BY PANCREATIC TUMORS.

(*c*) If the cyst spring from the lower portion of the head of the pancreas, or from the inferior border of the body or tail, it will develop at the lower limit of the lesser sac. As it then increases in size, it will push its way between the layers of the transverse mesocolon or bulge downward the inferior layer. In the former case, the transverse colon will run directly across the front of the cyst; in the latter, the transverse colon and the stomach will both be pressed upward.

Treatment.—Pancreatic cysts may be treated in one of the following ways: 1. Aspiration (Recamier's method).

2. Evacuation and drainage (Gussenbauer's method); marsupialization.

3. Extirpation; partial or complete.

1. **Aspiration.**—This method was adopted in some of the earlier cases. It has now, very properly, been abandoned.

2. **Evacuation and Drainage.**—This operation is the most generally applicable.

The abdomen is opened slightly to one or other side of the median line above the umbilicus. The cyst is exposed by dividing its peritoneal coverings, which vary according as the cyst is above or below the stomach. As a rule, it is reached by tearing through the great omentum just below the stomach. The cyst being exposed, the abdominal cavity is protected by flat swabs, which surround the most prominent part of the cyst. Into this a large aspirating needle is plunged and the greater part of the contents of the cyst are withdrawn. The puncture in the cyst wall is then freely enlarged; the cavity of the cyst is temporarily packed with gauze to prevent the escape of fluid from the interior, and the edges of the opening are sutured to the parietal peritoneum. If the cyst is very large a part of its redundant walls may be excised. A large drainage tube is then introduced, which, after two or three days, may be replaced by a Colt's suprapubic drainage apparatus. Cotterell and Pearce Gould secured drainage through a stab wound in the loin, and Peters, in a case of hydatid cyst of the tail of the pancreas performed the operation entirely through a lumbar incision. In some instances it has been found that a fistula through which pancreatic juice is discharged may remain for months after this operation. In one of my own cases it was only after eighteen months that healing took place. When the opening closes, the cyst may re-form.

In many of the earlier cases the opening of the cyst was deferred until some days after the wall had been sutured to the peritoneum, the operation being performed in two stages.

Extirpation.—This operation can rarely be performed, the adhesions are so numerous and so firm, the hemorrhage so free, and the pancreas so readily damaged. In a few cases, however, where the pedicle is small and devoid of vessels, the operation is very simple and easy.

If there is any possibility of the cyst's being malignant in character, a serious effort must be made to remove it. Delagenière advises opening the cyst after its contents have been aspirated and exploring

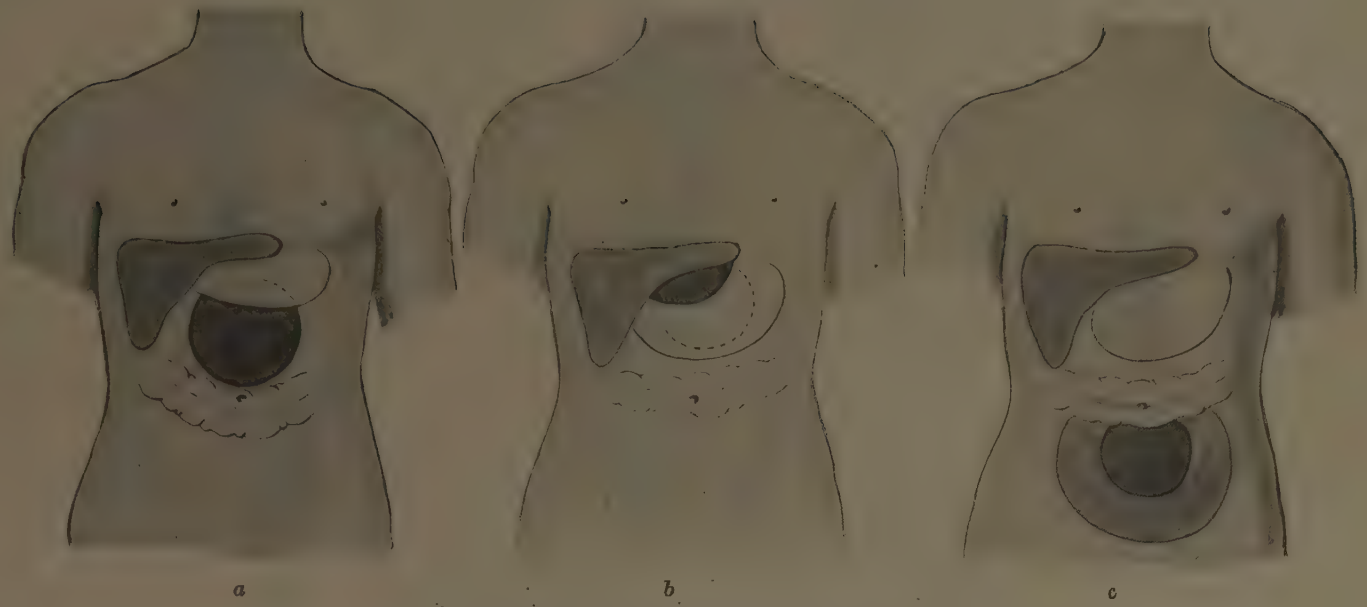

FIG. 549.—PANCREATIC CYST OR TUMOR.

a, Presenting between the stomach and transverse colon; *b*, presenting above the stomach; *c*, presenting below the transverse colon.

its inner surface. If little intracystic growths are felt, they are an indication of malignancy; if the cyst wall is smooth and pieces of grit or a stone are felt, the condition is one of retention-cyst.

Villar[28] in his recent work on the pancreas (p. 255) has collected the records of 13 cases operated upon by evacuation and drainage in two stages; all the patients recovered, but one died later of diabetes, and in some a fistula persisted for several months.

The opening and draining of the cyst in one stage had been performed in 125 cases with 7 deaths; in 3 cases no result was mentioned. Several patients died later from diabetes.

Total extirpation had been performed in 26 cases with 2 deaths.

In addition, 6 cases of hydatid cyst of the pancreas had been operated upon, all the patients recovering.

TUMORS OF THE PANCREAS.

Carcinoma.—This is the most common neoplasm of the pancreas. It may be primary or secondary, more commonly the latter, on account of the frequent implication of the gland in extensions of disease from

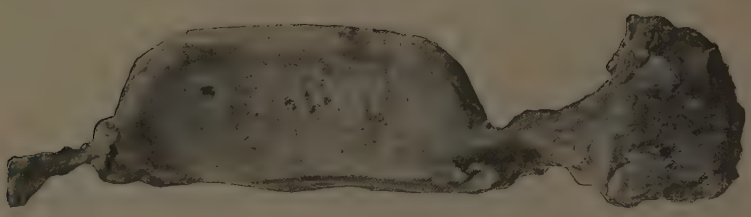

FIG. 550.—SECTION OF THE PANCREAS IN THE MIDDLE OF WHICH IS A LARGE, OVAL MASS OF HARD CANCER.
Museum of Royal College Surgeons, England, No. 2835 (Sir James Paget).

the stomach. In primary disease, the head of the gland is most frequently affected; the growth then extends either to the right, involving

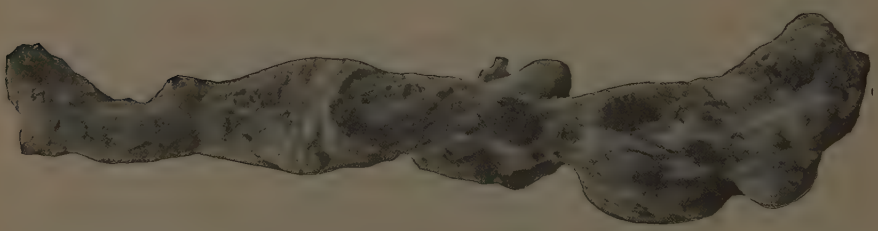

FIG. 551.—SECTION OF A PANCREAS IN WHICH THERE ARE NUMEROUS MELANOTIC GROWTHS OF VARIOUS SIZES AND SHAPES.
The specimen was taken from a girl twenty years of age, whose eye, containing a melanotic growth, was removed three years before her death (Museum Royal Coll. Surg., Eng., No. 2836).

the common bile duct and the pancreatic duct, or upward and forward, involving the common duct and the pylorus, or backward toward the vena cava and the portal vein. A different type of symptoms is pro-

duced in each case, pyloric obstruction being a characteristic of the second group and ascites of the third. The typical case history is this:

A patient of middle age suffers for a time from vague digestive discomforts, accompanied by weakness and loss of weight. Gradually jaundice develops, coming painlessly, increasing insidiously, never lessening. At last the jaundice is intense, of a deep green-black tinge. The gall-bladder gradually distends, and to the inner side of it a tumor is felt, well or ill-defined as the case may be. There is intense prostration, feebleness, lassitude, and wasting is rapid and extreme. Steatorrhea and azotorrhea are present in the characteristic white bulky motions, and glycosuria may rarely be found, when the destruction of the gland is so extensive that the islands of Langerhans are involved.

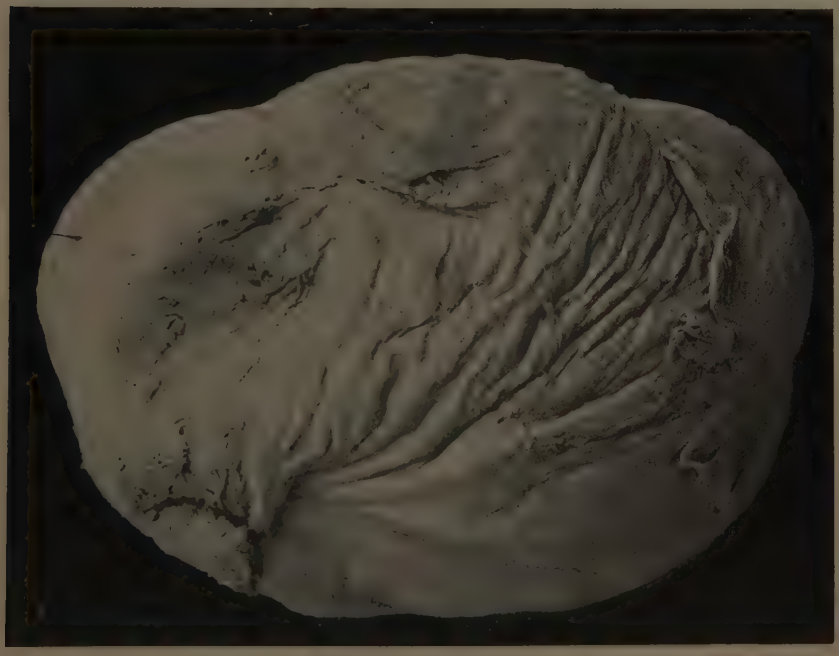

FIG. 552.—TUMOR REMOVED FROM THE TAIL OF THE PANCREAS.
Museum Royal Coll. Surg., Eng., No. 2836A (Malcolm's case).

As a rule, the differential diagnosis between cancer and chronic pancreatitis is easily made. It is most important that it should be made, for surgical treatment in cancer has a prohibitive mortality, whereas in chronic pancreatitis the results are excellent.

The association of chronic jaundice with distension of the gall-bladder is almost a pathognomic sign of cancer of the head of the pancreas. This was first noticed by Courvoisier, whose statement is embodied in what has since been known as Courvoisier's law.

"In cases of chronic jaundice due to obstruction of the common duct, a contraction of the gall-bladder signifies that the obstruction is due to stone; a dilatation of the gall-bladder that the obstruction is due to causes other than stone."

Sarcoma.—Primary sarcoma of the pancreas is very infrequent; secondary growths, especially in melanotic disease, are less uncommon. A few cases of successful removal of these tumors are recorded.

Adenoma of the pancreas has been recorded on 5 or 6 cases. In 1 case Biondi excised a fibro-adenoma from the head of the gland successfully. Other tumors are excessively rare.

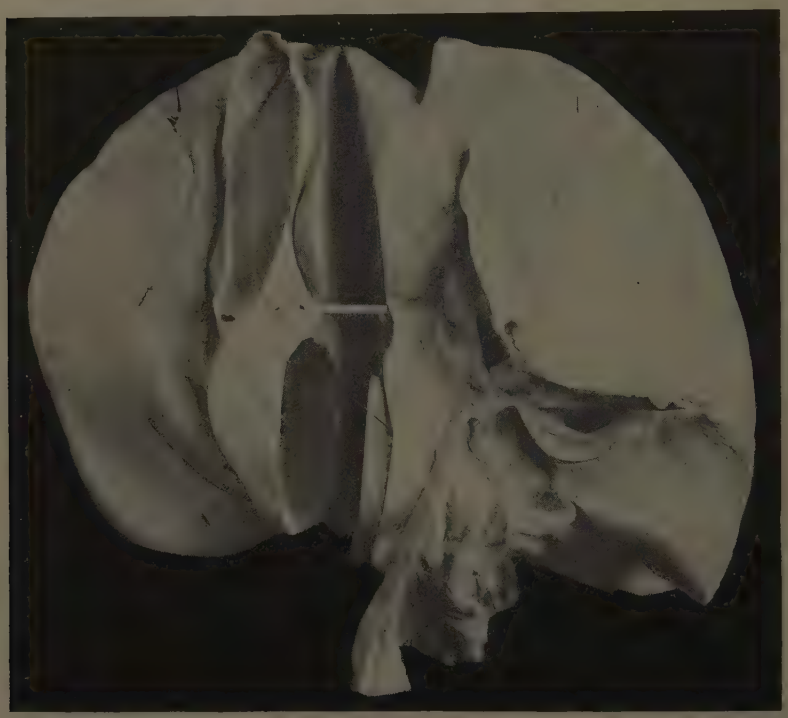

FIG. 553.—UNDER SURFACE OF THE LIVER, PARTS OF THE STOMACH, DUODENUM, AND GALL-BLADDER AND THE DIVIDED PORTAL VEIN GREATLY DISTENDED.
Museum Royal Coll. Surg., Eng., No. 2836B (Malcolm's case).

Treatment.—Villar[28] records 2 cases of partial pancreatectomy for simple tumor with 2 recoveries; 13 cases for malignant tumors with 5 recoveries and 8 deaths. Franke records 2 cases of complete pancreatectomy for cancer, both patients recovering.

WOUNDS OF THE PANCREAS.

Wounds of the pancreas are very infrequent. The depth of the organ within the abdomen, its protection by other viscera, and the partial shelter afforded by the costal arch all render its injury unlikely. It is found that in almost all cases of injury to this gland the blow has been of great severity, and many other structures are implicated. The liver, the kidneys, the spleen, the intestine large or small, or the

stomach may all be injured. As a general rule the injury is inflicted chiefly upon the epigastrium by the kick of a horse, by the pole of a carriage, or the patient is crushed or run over, or the wound may be caused by a stab or by a gunshot.

Symptoms.—The symptoms caused by a wound of the pancreas depend not so much upon the injury the gland has sustained as upon the concomitant injury of other viscera. If the pancreas alone be damaged, or if the injury of other parts is slight, the patient may at first feel little the worse. In 1 case, related by Ninni, the patient was able to run 500 yards after being shot through the abdomen, though the bullets had traversed the pancreas and had made seven wounds

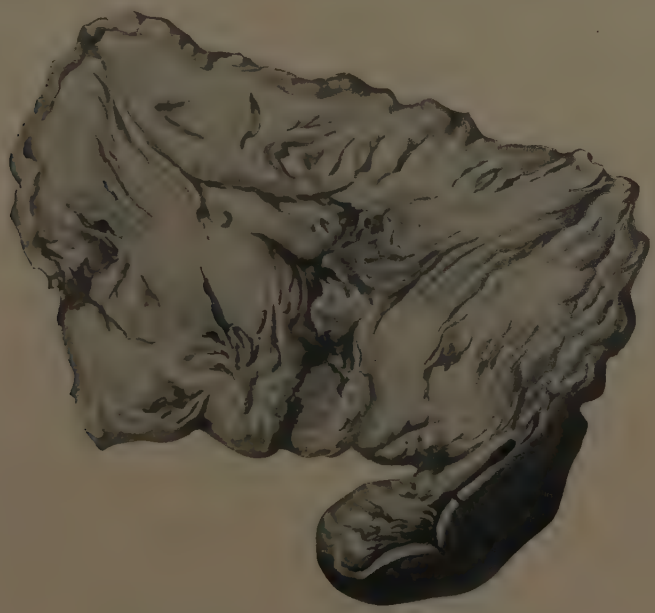

FIG. 554.—RUPTURE OF THE PANCREAS. (Leith.)

in the bowel. If the liver or spleen be injured hemorrhage will be profuse, and will be the chief reason for operative interference.

An accurate diagnosis of the seat of injury has not been made in any published case; the lesion has been discovered post mortem, or an operation has been undertaken upon a diagnosis of rupture of the liver, spleen, or bowel. Within a few hours of the receipt of the injury the symptoms of peritonitis set in, the abdomen becomes rigid and distended, the pulse-rate rises, vomiting occurs, and the patient looks ill and anxious.

In a certain very important class of cases the symptoms of any serious injury may at the first be absent, but during the first few days or weeks after an injury a swelling may develop in the epigastrium, which at the time of operation may be found to be a blood tumor

connected with the pancreas, or a hematoma of, or a fluid effusion into, the lesser peritoneal sac.

Treatment.—In a not inconsiderable number of cases where operative measures have been adopted and a rupture of the liver or spleen or stomach has been detected and treated, an injury to the pancreas has passed unnoticed and has led to a fatal issue. It must accordingly be considered an essential part of every operation for trauma in the upper abdomen, to inspect the whole length of the pancreas. If a punctured or incised wound of the pancreas be found, the two edges must be sutured accurately together by deep sutures of stout

FIG. 555.—COMPLETE TRANSVERSE RUPTURE OF THE PANCREAS. (Garrè.)

catgut, the duct being avoided, and the peritoneal edges over the wound approximated by fine catgut sutures, continuous or interrupted. If there is a gunshot wound the pancreas must be sutured, if possible, but if the gland is partly reduced to pulp or extensively bruised hemorrhage must be arrested and free drainage afforded. In many if not in most cases posterior drainage is much more efficacious than drainage by the anterior route.

Garrè[29] has recently recorded a case of complete transverse rupture of the pancreas; the torn edges were brought into exact apposition and

with three posterior and three anterior fine silk sutures passing through capsule and parenchyma, the defect was repaired and the hemorrhage stopped. Free gauze drainage was used, and the patient made an excellent recovery. This case and recent cases of pancreolithotomy have shown that the pancreas can be incised and the wound repaired by suture with perfect success. It is necessary to obtain perfect apposition of the cut edges, to arrest all bleeding, to avoid transfixing the canal of Wirsung, and to provide drainage if the wound is extensive.

Walther and Guillemin[30] record a case of recovery after complete transverse division of the pancreas. The gland was so bruised that suture was impossible, and a Mikulicz drain was therefore introduced.

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CHAPTER LII.

SURGERY OF THE SPLEEN.

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Anatomy.—In the adult the spleen weighs on an average about 150 grams, but it is liable to great variations in size.

It is usually described as resembling in shape an irregular tetrahedron, possessing phrenic, renal, gastric, and basal surfaces. It is almost entirely covered with peritoneum and is situated behind the fundus of the stomach, being covered by the lower ribs.

The outer or phrenic surface is the most extensive, it is convex and lies against the diaphragm which separates it from the ninth, tenth, and eleventh ribs; its long axis, measuring five or six inches, coinciding with their direction. In its upper part it is also separated from the costal wall by the left pleura and lung.

The other three surfaces are moulded upon abdominal viscera and are liable to great variation. The gastric surface is concave and rests upon the fundus of the stomach; it is separated from the phrenic surface by the anterior border, which commonly presents one or more deep notches. Within the confines of this surface is situated the hilum for the entry and departure of the splenic vessels.

The renal surface is applied to the upper and outer part of the anterior surface of the left kidney and usually overlaps the summit of the suprarenal capsule.

The basal surface of the spleen bears a varying relationship to the splenic flexure of the colon and the tail of the pancreas. The extent to which the tail of the pancreas comes into relationship with the spleen may vary considerably; it very frequently encroaches on the gastric surface in its lower part as far forward as the hilum.

The peritoneal attachments of the spleen are three:

1. The lienorenal ligament, a double fold of peritoneum which passes from the intermediate border of the spleen to the anterior surface of the left kidney.

This peritoneal attachment only partakes of the nature of a ligament when the spleen is drawn forward, *in situ*, the two folds forming it passing off to the right and to the left on the posterior abdominal-wall, the tail of the pancreas and the splenic vessels separating them widely.

2. The gastrosplenic omentum is a longer and more delicate fold, which passes from the hilum of the spleen to the fundus of the stomach; between its layers run the left arteria gastro-epiploica and the vasa

brevia, branches of the splenic artery. This fold is continuous below with the gastrocolic omentum.

3. The lower end of the spleen is supported by a peritoneal shelf, the costocolic ligament, formed by a fold of peritoneum passing from the diaphragm opposite the tenth and eleventh ribs to the splenic flexure of the colon.

Not only in its size, but also in its form the spleen is liable to great variations, and the conventional description may be widely departed from, particularly in the neighborhood of the hilum where all degrees of lobulation may be met with, even to the extent of separating small portions of spleen tissue from the main body of the organ. These detached nodules are termed splenculi and are usually met with in the

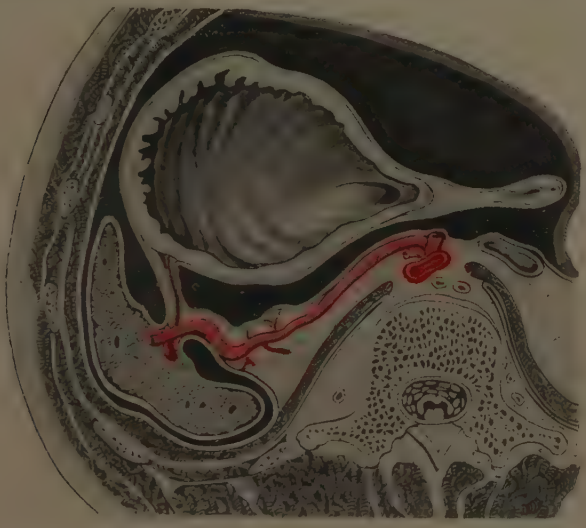


FIG. 556.—TRANSVERSE SECTION OF SPLENIC REGION. (From Testut.)

gastrosplenic omentum, but they may be found even in the great omentum.

The spleen receives its blood-supply from the splenic artery, a branch of the celiac axis. This vessel breaks up between the layers of the lienorenal ligament into five or six branches which enter the hilum of the spleen. The blood returning from the spleen is poured into the portal system through the splenic vein.

The spleen may be marked out upon the back by drawing two horizontal lines from the spinous processes of the ninth dorsal and first lumbar vertebræ; these are joined by a vertical line 4 cm. (1½ inches) to the left of the midline of the body, and another corresponding with the left midaxillary line. Within this quadrilateral space the spleen lies obliquely beneath the ninth, tenth, and eleventh ribs.

Functions.—Our knowledge of the functions of the spleen is meagre and unsatisfactory. The spleen is an organ which is peculiar

to the red-blooded vertebrates; it is in the spleen alone, among all the parts of the body, that the blood is brought directly into contact with the actual substance of the organ. The spleen is, indeed, a sort of blood filter. It would seem to be the chief of its functions, as first suggested by Kölliker, to arrest and take up from the blood in its passage through the interstices of this glandular filter particles of foreign matter, and effete red blood-corpuscles. Both Kölliker and Ecker described the spleen as a scavenger for the dead erythrocytes. They found in the blood of the spleen large, white protoplasmic cells, possessed of ameboid movement, in the interior of which, red cells in various stages of disintegration were found. The hemoglobin liberated by this cellular destruction forms the basis of the pigment of the spleen, which is a substance allied to hematin. Phagocytosis, it would appear, is normal and constant in the gland; it can be seen at all times and in all stages.

Among the functions which have been assigned to the spleen is that of forming the red blood-cells, or converting the leucocytes into red corpuscles. In the lowest order of vertebrates, the fishes Bizzozero and Torre[1] have shown that all the red corpuscles are made in the spleen; the bones contain no marrow.[2] In the spleen they always found red blood-cells with dividing nuclei. In the lower reptiles the marrow of the bones is simply fat; the spleen, always showing an abundance of red cells with dividing nuclei, is the only organ where the red corpuscles are formed. In the higher reptiles the bone-marrow begins to take a part in the formation of the cells, and in birds this function is fulfilled by both the spleen and the bone-marrow. In man the bone-marrow is undoubtedly the chief source of the red cells, but the spleen not improbably plays a part therein, at least in fetal life or in the period of early infancy. As a producer of the white corpuscles, the spleen, according to the most recent investigation, plays a part that is subsidiary to that of the bone-marrow and the lymphatic glands. Starling considers that the evidence that red cells are formed in the spleen is inconclusive.

Apart from its influence in one direction or another upon the blood, the spleen probably exerts other actions. There is possibly a connection between the spleen and the formation of uric acid. A substance "protrypsin" may be formed by the spleen which, passing into the blood, is elaborated by the pancreas into trypsinogen. For after the removal of the spleen, the production of trypsin by the pancreas is said to be diminished; whereas, if an extract of spleen be injected into the circulation of a spleenless animal the amount of trypsin is increased.

The size of the spleen varies from time to time, as was first shown by Roy. This variation which is permitted by the loose structure of the spleen may be controlled by the involuntary muscle-fibers present in abundance in its capsule. Roy, working with his oncometer, demonstrated the existence of rhythmic contractions in the spleen, due to the alternate contraction and relaxation of the capsular muscle. The spleen is increased in size some hours after a meal, at a time when,

according to Litten, "the digestive organs, after a period of activity, are no longer engorged with blood; it is possible, therefore, that the spleen is a regulator of the blood-supply for the digestive organs."

As is well-known, the spleen is liable to undergo great enlargement in the acute infectious diseases. The precise significance of this change is not yet understood.

EFFECTS OF REMOVAL OF THE SPLEEN.

The spleen is an organ which is not essential to life or to health. Whatever the range of its functions may be, it is certain either that these are not indispensable to the economy or that they are assumed after ablation of the gland by other organs or tissues of the body. A few cases are recorded in which the spleen was congenitally absent. A complete record of such cases is given by Hodenpyl,[3] 1 of the cases occurred in a woman of seventy-three.

The most important of the changes which ensue upon the removal of the spleen are those which occur in the blood. Briefly these are (*a*) an increase in the number of the leucocytes (*b*) a decrease in the number of the red corpuscles. (In a very few cases an early and transient slight increase in the red cells has been observed.) (*c*) A diminution in the amount of hemoglobin. These changes attain their maximum at a time which varies between two weeks and two months, and the blood condition then gradually returns to the normal. After the lapse of two months or a little longer there is lymphocytosis, which is invariable and not dependent upon the nature of the condition for which the spleen was removed. After many months a moderate eosinophilia may appear, and according to Cabot[4] the mast cells are then increased.

In many of the carefully recorded cases of splenectomy a general enlargement of the lymphatic glands has been observed. In 3 cases recorded by Ballance[5] it was a pronounced feature. The work of Warthin[6] upon the sheep and goat seems to have established the fact that the lymphatic glands take upon themselves a part at least of the work normally done by the spleen. In his investigations upon the spleenless sheep he describes a "hyperplasia of existing lymphoid tissue, transformation of hemolymph nodes into ordinary lymphatic glands, and a new formation of hemolymph nodes out of lobules of fat tissue, and a later proliferation of the red marrow." He believes that a hemolytic function is assumed by the hemolymph nodes and lymphatic glands, and that this may exceed the blood-destroying function of the spleen itself. The new formations in the lymphatic system have been verified by several observers. Tizzoni saw new developments of nodules resembling splenic tissue in the mesentery of horses and dogs deprived of their spleens. Moster found the same condition of "telangiectatico-hemorrhagic lymphomata" in the omentum and mesentery of the dog after splenectomy.

The changes in the bone-marrow account, it may be, for that pain

in, and tenderness along, the bones of the limbs which in not a few cases has been a matter of serious concern to the patient. Emelianow[7] studied the bone-marrow changes after extirpation of the spleen in seventeen dogs. The alterations were demonstrable within a few hours of the operation. The fat was broken up and emulsified, and complex changes followed until the marrow came to resemble the looser spleen pulp and to be rich in nucleated red cells. Riegner[8] was able to demonstrate a greatly-increased medullary activity in the tibia of a limb removed from a patient upon whom he had performed splenectomy four weeks before. The popliteal lymphatic glands were also enlarged. The changes in this case were, however, possibly altered by the fact that the spleen was removed for rupture after a very severe hemorrhage had occurred.

In many of the records of cases it is stated that pyrexia has been present for some time after the removal of the spleen, but it is not at all certain that this was due in any degree to the nature of the operation performed. The possibility of a mild septic infection cannot be excluded in any of the cases.

Other symptoms which have been observed are loss of weight, great thirst, intense prostration with attacks of faintness, polyuria, enlargement of the thyroid gland, and abdominal pain and tenderness (possibly due to enlarged mesenteric glands).

Noel Paton,[9] after a long series of experiments upon the metabolic processes of the spleenless dog, came to the following conclusions: (1) That there is a more rapid excretion of water after a meal, probably indicating a more rapid absorption, and (2) that there is no essential difference in the course or nature of the metabolism either during fasting or after feeding with the ordinary proteids of flesh, with vegetable foods such as oatmeal, or with food rich in nucleins, such as thymus gland.

It is interesting to note that Tizzoni[10] who removed the spleen in a large number of dogs, of all ages, found that the effects produced in the blood were less noticeable in the younger dogs than in the older ones, owing to a greater activity in the organs which compensate the abolished function of the spleen. He has also shown that in man the removal of a diseased spleen produces less effect on the blood than the removal of a healthy gland, because in the former circumstances the compensation for the decreased activity of the spleen is already partly or completely established.

It has been suggested, and to some extent experimental work supports the opinion, that after the removal of the spleen the individual becomes more easily susceptible to an infection. The results of the investigations are up to the present, however, very conflicting and no valid opinion can be expressed upon the point.

Vulpius,[11] in his elaborate work upon the effects of the removal of the spleen, stated that the regeneration of blood after a severe hemorrhage is probably slower and feebler in those who have lost the spleen.

So far as the late after-results of splenectomy are concerned there has been little recorded. The fullest and most satisfactory report is that of Bland-Sutton,[12] who has given details of 7 cases operated upon by himself, in none of these was there any ill-result from the loss of the spleen.

MOVABLE (WANDERING) SPLEEN.

The spleen which normally has only a very slight range of movement may become so mobile, in exceptional circumstances, that it will lie in any part of the abdomen. It may wander easily from one part of the abdomen to another, and be readily replaced in its normal position, or, having strayed far, it may become fixed by adhesions in its new and abnormal position. It is then known as a dislocated spleen. The condition is far more common in women than in men:

Etiology.—The causes of movable spleen are:

(*a*) Congenital elongation, or rupture of the peritoneal folds which hold the spleen.

(*b*) Increase in size of the spleen, causing a dragging upon and a yielding of its suspensory apparatus.

(*c*) General laxity of the abdominal walls, with looseness of all the viscera, as in Glénard's disease, or after repeated pregnancies.

Undue length of the suspensory ligaments of the spleen is far more commonly due to the dragging of an enlarged and weighty organ than to congenital causes. It is, however, undoubted that such a congenital anomaly exists, for I have seen the spleen of a boy of twelve so mobile that it would lie in the left iliac fossa. In many cases a history of an initial sudden displacement of the spleen suggests that laceration of the ligaments may then be a responsible factor.

The spleen when mobile makes wider excursions in the abdominal cavity than any other organ. It may lie in any position, and its occupancy of the pelvis is so frequent that an erroneous diagnosis of ovarian or uterine tumor is commonplace. It may be moved about freely within the abdomen by the surgeon's hand; when the patient turns from side to side it drops to that side which is lowest, though at times, as Bland-Sutton[13] observes, it seems to float upward on the intestines, "like a boat on the crest of a billow." Morgagni observed the spleen in the sac of an inguinal hernia. In almost all the cases, but certainly not in all, the vagrant organ is enlarged; such enlargement may be primary and causal, or due to secondary engorgement.

The **results** which may follow upon displacement of the organ are:

(*a*) **Engorgement.**—The normal structure of the spleen is one eminently capable of engorgement. The organ varies considerably in size as we know, from time to time, and owing to the presence of unstriped muscle fiber in its capsule it undergoes rhythmic contraction and relaxation. When displaced it may undergo very considerable engorgement.

(*b*) **Rotation of the Pedicle.**—When the stalk by which the spleen is held is long, axial rotation is apt to follow. The symptoms which

attend this disaster are very closely similar to those caused by the twisting of the pedicle of an ovarian cyst. They have suggested a diagnosis of acute peritonitis or acute intestinal obstruction in some of the recorded cases.

Axial rotation of the pedicle may occur slowly, the result being a gradual engorgement of the organ, or acutely, the result being an intense congestion of the gland accompanied by hemorrhage into its

FIG. 557.—CHILDE'S CASE OF SPLENECTOMY FOR MOVABLE SPLEEN WITH TWISTED PEDICLE.

The patient was a spare woman of fifty-four, who had had nine children. There was a largish tumor occupying the false pelvis and lower abdomen chiefly upon the left side. The tumor was smooth, rounded, and of fluid consistence. No tumor could be felt in the pelvis on vaginal examination, but there was a sense of resistance in front and to the left of the uterus; the uterus was retroverted. A diagnosis of ovarian cyst was made. An acute illness the patient had had a short time previously was ascribed to rotation of the pedicle of the cyst with hemorrhage into its cavity. At the operation a large blood cyst was found. On stripping adhesions from it, a dark mass which looked like a coil of engorged intestine came into view; this proved to be the upper pole of the spleen. Into the lower part of the gland a hemorrhage occurred between the capsule and the surface of the gland. The pedicle of the spleen was twisted.

substance, the formation of infarcts, evidences of gangrene, or acute peritonitis.

As a result of the engorgement of the organ due to a rotation of the pedicle, a vessel, or vessels, may give way, and a large hemorrhage, subcapsular or parenchymatous, may occur. Childe[14] records such an example, which is shown in the annexed photograph with which he has kindly supplied me (Fig. 557).

Subbotic[15] records a case in which a multilocular cyst the size of the fist was found in the spleen of a woman. The pedicle was twisted, and an acute peritonitis had followed which bound the spleen firmly to the omentum, the uterus, and the cecum.

In several recorded cases a patient, who was apparently in perfect health, suddenly experienced an attack of severe abdominal pain, followed by the appearance of a tense and tender swelling, abdominal tenderness, rigidity, vomiting, and prostration. In other cases the acute onset and the rapidly following signs of peritonitis have called for operation, in the belief that a strangulation of the gut by a band, or a perforation of some part of the intestine had occurred. In one case the enlarged adherent organ so compressed the transverse colon as to cause chronic intestinal obstruction upon which an acute obstruction supervened; in others a diagnosis of subphrenic abscess has been made. The extent to which the pedicle is twisted varies much. In Subbotic's 4 cases there was a twist to 180° in 2 cases, to 360° in 1 case, and to twice 360° in 1 case. The vessels of the pedicle are always thrombosed. In many of the recorded cases a primary splenomegaly has existed, most often of the malarial type.

After axial rotation has occurred the spleen may remain fixed, adherent, and tender for many months. Bonmarito relates 1 such case where the spleen became fixed in front of the uterus. Every month the organ became swollen and tender, and the patient suffered for 8 days from pain and vomiting. Atrophy may occur as a late result.

The excursions of a mobile spleen produce changes in other viscera. The pancreas is sometimes quite unaffected, at other times it is pulled upon and displaced. In 1 case recorded by Rokitansky the tail of the pancreas was so pulled out that it measured ten inches in length, and formed a part of a twisted pedicle, being wrapped three times round the artery. Richelot and Bland-Sutton have both had to cut through the tail of the pancreas in performing splenectomy. The stomach, as one would suppose, is dragged upon, and it may be distorted by a shifting spleen. Pain, vomiting, and gastric uneasiness result. The intestines may be compressed by, or become adherent to, the spleen, and finally the pelvic organs may suffer. An engorged spleen may become firmly adherent to them, or a weighty spleen may press upon the uterus and cause displacement. Kouwer has published details of a case in which a pelvic spleen caused complete prolapse of the uterus, vagina, and bladder.

Treatment.—The most appropriate treatment for a wandering spleen would at first thought seem to be its fixation in its natural position by the operation of splenopexy. But in practice it is found that few of the spleens which are so mobile as to attract attention are healthy; they are so damaged by pre-existing disease or by the changes which ensue upon rotation of the pedicle that splenectomy has to be performed very frequently. If, however, a mobile but otherwise normal spleen be encountered the operation of splenopexy may be

performed; it is safe, and its results so far as can be ascertained are satisfactory.

Bessel Hagen records between 1891 and 1900 15 cases of wandering spleen, enlarged by malaria, treated by splenectomy with 1 death, and 28 cases of idiopathic hypertrophy of the wandering spleen with 2 deaths.

ABSCESS OF THE SPLEEN.

The occurrence of abscess of the spleen is decidedly rare. It is customary to consider the abscess as primary or secondary; primary when the suppuration occurs in the spleen alone, all other organs being healthy; secondary when infection of the spleen is demonstrably the result of a primary disease elsewhere.

Primary abscess of the spleen is a possibility, but a fanciful one. I have not discovered any indisputable evidence of its existence. It is said to have followed injury or a strain, but has then probably been due to infection subsequent to the development of a hematoma. It has been attributed to a "chill," but it is more probable that the chill was the initial manifestation of the abscess.

Secondary abscess of the spleen is almost constantly, if not invariably, the result of an embolism or of a hemorrhage into the gland; a septic process developing later. Leyden considers that all abscesses of the spleen have their origin in embolic infarcts or metastatic inflammation. In some cases, however, the spleen may be involved by reason of its contiguity to a suppurative lesion originating in any neighboring structure, and extending widely irrespective of the organs it invades.

The causes to which secondary abscesses of the spleen have been attributed are many. In the great majority of cases the suppuration occurs in the course of acute infective diseases, such as typhoid fever, smallpox, recurrent fever, malaria, and acute rheumatism. In other instances an acute septic disease originating elsewhere, especially within the portal area, is the starting point of the infection; of such are appendicitis and pyosalpinx. In these cases an infected embolus is carried from the inflamed area in which thrombosed veins are found. Other causes are leukemia, scurvy, fracture of the rib, or other injury causing hemorrhage within the substance or beneath the capsule of the gland, and malaria.

Anderson[16] has lately drawn attention to the occurrence of splenic abscess in connection with malarial fever. During five years 77,949 patients suffering from malarial fever were under his care. Of these, only two were recognized during life to be suffering from abscess of the spleen. On examining the available post-mortem records of death from malaria it was found that in 3 instances only was splenic abscess present. A good account is given of the 2 cases in which an abscess in the spleen was correctly diagnosed during life. One of the patients recovered, whilst the other died. The patient who recovered was a Hindu male, twenty-five years of age, who was admitted into hospital for fever and enlarged spleen in April, 1901. A few days after admis-

sion marked tenderness, spontaneous pain, and slight localized bulging over part of the anterior border of the spleen, accompanied by fever of a low remittent type, led to the suspicion of abscess of the spleen. The diagnosis was confirmed by puncturing the organ with a small aspirating needle. An incision was then made through the abdominal wall over the most prominent part of the swelling and about 1 pint of reddish pus was evacuated. Free irrigation with sterilized water was made, and on inserting a couple of fingers to discover the limits of the abscess cavity and to feel for possible neighboring abscesses, an odorless slough of splenic tissue, 270 grains in weight, was removed. Two drainage-tubes were inserted and complete recovery resulted. Anderson states that 3 of his 5 cases support the view that the abscess formation is due to infarction of the organ.

The spleen is generally enlarged, sometimes to a very considerable degree. It is adherent more or less intimately to the neighboring viscera, the stomach and the transverse colon more especially, to the abdominal wall, and to the diaphragm. The abscess, as a rule, is small and is surrounded by splenic tissue which has undergone a red consolidation described as "hepatization." In 1 case related by Leyden[17] fifteen litres of pus were found. The pus contained within the abscess cavity is generally rich in micro-organisms, but it has been found sterile. It may be thin and yellow, or thick and of chocolate color; odorless or smelling offensive or feculent. The abscess may burst externally, and the patient speedily recover; it may burst into the peritoneal cavity. Its discharge through the intestine, the stomach, the colon, the vagina, the pelvis of the kidney, the pleura, and into the splenic vein has been recorded.

Symptoms and Diagnosis.—The symptoms which are caused by the accumulation of pus in the substance of the spleen are apt to vary considerably. In some cases where the abscess is quiescent it may give rise to no symptoms, and the discovery of the condition may only occur at a post-mortem examination. In such instances a small, thick-walled cavity containing a few drams of pus is found. In other cases there may be an extremely rapid enlargement of the spleen, associated with rigors and persistent high temperature. In still others, a patient who has had a septic fever may continue to present all the indications of septicemia after the original focus has healed, and attention is directed to the spleen either by the occurrence of pain in the side or by the rapid enlargement of the organ. A mere enlargement of the spleen, however, is of no diagnostic significance, for it occurs as a constant condition in those diseases, typhoid fever for example, in which a splenic abscess is apt to form. In a few recorded cases, a diagnosis of subphrenic abscess has been made. In 57 cases of abscess of the spleen, collected by Grand-Mourcel,[18] a correct diagnosis was made in 14 only.

The outlook in these cases is bad. The death rate is estimated from recorded cases which probably present the most favorable aspect at from 70 to 80 per cent. In 17 cases of typhoid abscess recorded by Esau[19] 4 recovered, a mortality equivalent to 77 per cent. The patients

affected by this disease are always weakened, sometimes to a very serious degree, by the disease to which the abscess is secondary.

Treatment.—When a diagnosis of splenic abscess has been made, surgical treatment should be adopted forthwith. If the abscess is pointing it must be opened at the spot which presents. In other cases the abdomen is opened and the abscess drained, or the spleen may be excised. The abscess has been found containing large sloughs of the organ. There are cases in which the transpleural route is preferable, one or more portions of ribs being excised and the diaphragm cut through.

TUBERCULOSIS OF THE SPLEEN.

Tuberculosis of the spleen very rarely attracts clinical recognition, though it occurs not uncommonly as a part of a widely spread tuberculous infection. Primary tuberculosis is rare, though its existence would seem indisputable. In the majority of observed cases the affection of the spleen has been subsidiary in importance to the disease in other organs. It is chiefly when the enlargement of tubercle is combined with undue mobility of the gland that the patient's attention is attracted to the condition.

Rilliet and Barthez,[20] in 312 cases of tuberculosis in children, found 264 in which the lung was affected, and 107 in which the spleen was attacked. In adults, Rokitansky found, among 104 cases of fatal chronic pulmonary tuberculosis, 11 cases in which the spleen was diseased.

The deposit of tubercle in the gland may be of the acute miliary type, or of the chronic, caseating form. In both the spleen is enlarged, and in the latter is hard and often nodular upon the surface.

Bessel Hagen[21] found 1 unsuccessful case of splenectomy recorded for tuberculous disease prior to 1890, and between 1891 and 1900 2 cases (Bland-Sutton[22] and Marriott).[23] Since 1900 3 additional cases have been recorded (Carle, Grillo, Lannelongue). Bland-Sutton's case occurred in a female patient aged twenty-one; she complained of a swelling in the left half of the abdomen which she had noticed during the puerperium two years before. This swelling had an oval contour and could be easily moved about the abdominal cavity. It seemed to float upon the intestines, and when manipulated into the loin could be turned upon its edge so that it could be recognized as discoid. No notches were detected. The dragging sensations caused much discomfort and distress and made operation desirable. But tubercle of the lung was present, and an old cavity was found in the right apex. This, however, was quiescent; there was no cough, and there were no night-sweats. The temperature was normal. Splenectomy was, therefore, performed. The spleen was carefully examined and a few tubercle bacilli found in the nodules which dotted the surface. The operation was performed in Sept., 1897. Three years later there was "nothing to indicate that she was spleenless."

Marriott's[23] case concerned a female patient aged thirty-two, who

was admitted to hospital for a large abdominal tumor which had been noticed two years previously. The diagnosis was doubtful, and an exploratory operation performed. This revealed an enlarged spleen, which was removed. An examination of the specimen, which is now in the Museum of the Royal College of Surgeons, showed it to be tuberculous. Sir C. Marriott has kindly informed me that the patient operated upon in 1891 is now (1906) quite well.

Carle's[24] patient was a woman from whom a tuberculous spleen was successfully removed. Recovery was complete, and the patient subsequently bore two children.

Grillo[25] operated for "primary tuberculous splenomegaly," and removed the enlarged organ successfully. The patient was quite well fifteen months later.

Lannelongue and Vitrac[26] report a case of splenectomy for movable "primary" tuberculous spleen in a woman of thirty-eight. The glands in the hilum were also tuberculous. The patient recovered.

Franke[27] in recording 1 case of splenectomy for primary tuberculosis of the spleen says that in all 29 cases are recorded in the literature. In 10 the spleen was removed, 7 of the patients being thereby permanently cured.

The conclusions that we are entitled to draw from these experiences are that in cases of tuberculous enlargement of the spleen, apparently primary, and in cases of secondary affection of the spleen where distressing symptoms are caused by the wandering of the enlarged organ, splenectomy is an operation that should be practised. The results of this operation in the recorded cases has been satisfactory.

CYSTS OF THE SPLEEN.

Varieties.—Cysts of the spleen are of three varieties:[28 29 30]

1. Unilocular or multilocular cysts, not of parasitic origin. Serous cysts; blood cysts; lymph cysts.
2. Hydatid cysts.
3. Dermoid cysts.

1. Non-parasitic Unilocular or Multilocular Cysts.—(*a*) *Serous Cysts.*—The content of these cysts is a clear, pale, straw-colored fluid of a specific gravity of 1.004 to 1.009. The cysts are lined, as a rule, by a single layer of pavement epithelial cells.

(*b*) *Blood cysts.*—These are the most frequent of all forms of non-parasitic cyst. The appearance of a hemorrhagic cyst of the spleen varies according to its age. At first there is, of course, a collection of pure blood, the result of an injury to the gland. Later there are coagula, shreds of fibrin, amorphous deposits of blood pigment, cholesterin, and so forth, and the fluid in the cyst varies from a turbid yellow color to chocolate or dark-red. The hemorrhage which is the precursor of the cyst may be parenchymatous, but is more often subscapular; it is this which accounts for the frequency of the external adhesions, for a low-grade inflammation of the serous coat overlying the hematoma

is constant. There can be no doubt that many of the so-called "serous cysts" of the spleen are, in fact, hemorrhagic in their origin. The solid constituents of the blood are deposited laminally upon the wall of the cyst, the fluid contents becoming thereby clearer. On the other hand, it is probable that when a serous cyst has developed a hemorrhage may occur into it, causing a sudden and painful increase in its size. The two conditions of "serous" and "hemorrhagic" cysts cannot always be definitely separated from one another.

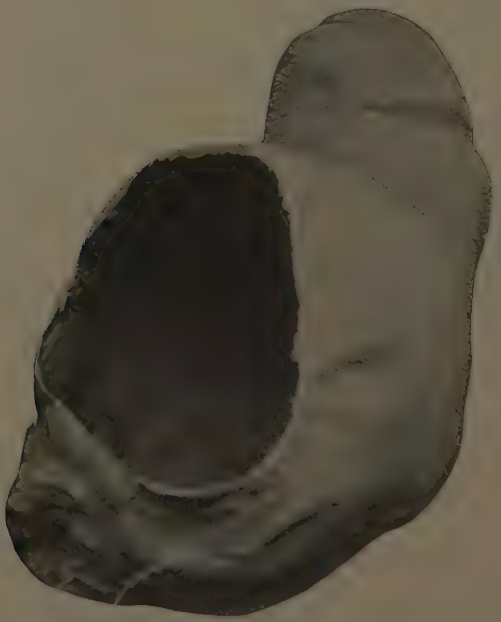


FIG. 558.—HEMORRHAGIC CYST OF SPLEEN.

A spleen the lower part of which is replaced by an oval cyst, measuring 6 inches in its longest diameter. The outer surface of the cyst is covered for the most part by a layer of peritoneum, continuous with that on the spleen, and has shreds of great omentum adhering to it.

At the seat of attachment to the spleen, the substance of that organ is flattened out and forms part of the wall of the cyst. The inner surace is marked by numerous interlacing bands of fibrous tissue, which appear to be remnants of the splenic stroma. In the recent state the cyst contained 3 pints of a brown thick fluid like broken-down blood. Microscopic examination shows that the wall is composed of fibrous tissue permeated with large vessels. Masses of partially organized clot and granular material containing blood crystals are attached to the inner surface of the cyst wall, but there is no distinct lining membrane.

From a woman, aged thirty-seven, who had noticed a swelling in the abdomen for eight years. It was very elastic, and as it appeared to fill the abdominal cavity as high as the umbilicus it was considered to be an ovarian tumor. For three months previous to the operation for its removal the tumor had enlarged rapidly. The patient made a good recovery and was in excellent health a year after the operation. (Museum Royal Coll. Surg., Eng., No. 2887A.)

Blood cysts have occurred more frequently in connection with spleens already affected by malarial enlargement. The greater size of the organ renders it more liable to traumatism.

(*c*) *Lymph Cysts.*—According to Litten some of the cysts of the spleen can be demonstrated, after removal, to be due to ectasis of the lymphatics. The fluid in these cysts is distinguishable from that in a serous cyst by having a much higher specific gravity, and by a tendency to spontaneous coagulation.

2. **Hydatid Cysts.**—These are the most common form of cyst of the spleen. Trinkler, in 2117 cases of echinococcus disease, found the spleen affected in 68 cases. There are frequently, but not constantly, evidences of hydatid disease elsewhere. The cysts are always unilocular, and may grow from any part of the organ; they are apt to undergo calcification. The fluid is of the usual character; it is thin, pale, limpid, of a specific gravity 1004 to 1010, it contains no albumin, is neutral or faintly alkaline in reaction, and contains inorganic salts in

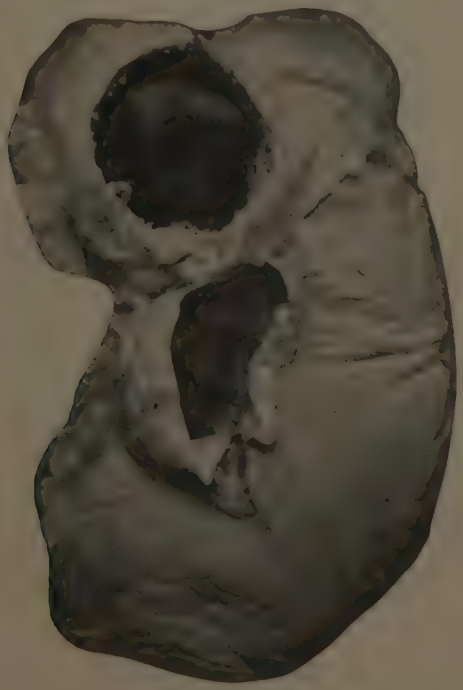


FIG. 559.—HYDATID CYST OF SPLEEN.

The spleen of a man from whose abdominal cavity several large hydatid cysts were taken. On its surface, and partly imbedded in it, are several thick-walled cysts of tough texture, which contained acephalocyst hydatids. The largest cyst has been emptied; its internal surface is uneven and has flakes of yellowish lymph deposited on it. In another cyst near it, and thickly lined with lymph, there is a mass, composed of rolled-up membranes of collapsed hydatids; and in another (at the back of the preparation) similarly rolled-up membranes have a deep amber color. In a fourth one several hydatids presenting their ordinary appearances. (Museum Royal Coll. Surg., Eng., Hunterian specimen, No. 2890.)

large quantities. Its characteristic and distinguishing feature is, of course, the presence of hooklets and scolices of the parasite. Litten records a case seen in the practice of Murchison, in which the cyst ruptured into the large intestine.

3. **Dermoid Cysts.**—So far as I can ascertain, the only case of dermoid cyst is that recorded in 1829 by Andral. The cyst lay in the center of the spleen had fibrous walls, and contained a thick fatty matter like tallow, in which many hairs were found.

Symptoms.—Cysts of the spleen, when of small size, give rise neither

to signs nor to symptoms. Many of the smaller cysts, especially those of the serous variety, have only been recognized on post-mortem examination. In a majority of cases a history of injury, speedily followed by the appearance of a tumor can be elicited. The larger tumors give rise to a feeling of weight or pressure. Pain is generally limited to the area occupied by the enlarged organ. In some of the recorded cases acute pain and vomiting have been observed. These may be due, as in a case of Bardenheuer's, to dislocation of the gland. Hydatid cysts grow commonly from the upper part of the gland. In their increase they cause an enlargement of the lower part of the chest

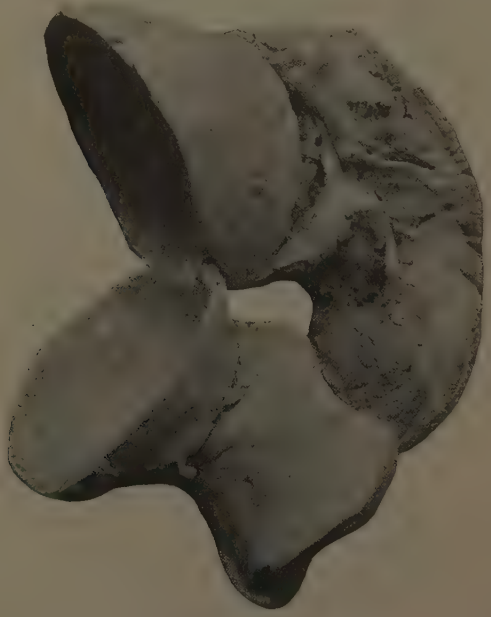


FIG. 560.—CYST OF THE SPLEEN.

A spleen, at one end of which, and partly imbedded in its substance, there is a globular cyst, such as may have contained hydatids, about 3 inches in diameter, with walls from half a line to two lines thick, and formed of a tough pale tissue in parts of which there are plates of earthy matter. The interior of the cyst is nearly smooth; a portion of liver is adherent to its external surface. The spleen is of natural size, but appears to have been of soft texture. (Museum Royal Coll. Surg., Eng., No. 2887.)

on the left side, and in some cases serious embarrassment of the action both of the lungs and of the heart, owing to upward pressure upon the diaphragm. The non-parasitic cysts develop almost invariably in the lower half of the spleen and grow downward. It is rare to find that any interference with the proper action of the other abdominal organs is caused. In many cases a peculiar "creaking" sensation is felt during respiration when the hand is placed over the tumor. This is due to perisplenitis; when the abdomen is opened it is seen that there are many flaky adhesions covering the surface of the cyst, and attaching it to the abdominal wall or other parts with which it lies in contact. It is the rubbing together of lymph-covered roughened surfaces which

gives the sensation, which is often compared to the creaking of new leather.

The most important and decisive symptom is, as Litten says, the discovery of a tumor with the characteristics of a cyst in the left hypochondriac region.

This tumor is continued upward beneath the costal margin, and on percussion its dulness is continuous with that of the spleen. In hydatid cysts the characteristic "thrill" is generally to be obtained.

The conditions from which an enlarged cystic spleen must be differentiated are: cystic kidney (hydronephrosis, etc.; cyst of the pancreas, or mesentery or omentum; hydatid disease of the left lobe of the liver; ovarian cyst.

In cases where the spleen has undergone dislocation, and has become fixed in its abnormal position, a correct diagnosis is impossible. The points which will enable an accurate diagnosis to be made are concerned with the site of the tumor, its place of origin, the direction of its increase, its mobility, and the symptoms which arise from pressure or from traction.

Treatment.—Of the *non-parasitic* cysts there are 31 cases recorded in which surgical treatment has been adopted. There were 8 males, 22 females; in 1 case the sex is not stated. The operations that have been practised are, simple puncture, incision and injection; incision and drainage, marsupialization, extirpation of the cyst, splenectomy. The operation to be preferred is undoubtedly splenectomy. The result of the other procedures is uncertain and in practice more serious. In Power's[31] series there were 10 cases of splenectomy; all the patients recovered. The only contra-indication to splenectomy is the presence of adhesions in such number and of such complexity as to make removal of the gland impossible or extremely hazardous. In such cases incision and drainage must be practised. In 5 cases so treated in Power's series, 3 recovered completely, in 1 a small sinus persisted, and in 1 death occurred from sepsis. In 3 cases marsupialization was performed, all the patients recovering.

If, by happy chance, a cyst should be found with a small pedicle attaching it to a spleen otherwise healthy, a partial resection of the gland might be performed.

In the treatment of *hydatid cysts* it is best to incise, evacuate, and drain. In some instances splenectomy may be necessary. Laspeyres[15] states that since 1894 there have been 14 cases of splenectomy, all the patients recovering.

NEW GROWTHS OF THE SPLEEN.

Primary growths in the spleen are of extremely rare occurrence, and are devoid therefore of any great clinical interest. Of the simple tumors, fibroma, lymphangeioma, adenoma, and lymphomata have been described; all of them by pathologists. So far as I can ascertain, there is no case recorded in surgical literature of a case of simple tumor

of the spleen being encountered accidentally or designedly during the course of an operation.

Malignant tumors of the spleen may be primary or secondary; the latter are probably the more frequent, but the former alone possess any living interest.

Sarcoma of the Spleen.—The first 2 cases of sarcoma of the spleen were recorded by Weichselbaum[32] in 1881. Both specimens were obtained in the post-mortem room. In the first the spleen was greatly enlarged, and presented growths throughout its structure. The specimen is classed as a "primary endothelial sarcoma" by Birch-Hirschfeld.[33] In the second specimen, a tumor springing from the substance of the spleen projected beyond its convex surface, from which it was easily enucleated. The tumor was a "primary fibro-sarcoma." Before these 2 cases were recorded, Friedreich[34] in 1865 reported a case of "multiple nodular hyperplasia of the liver and spleen," which is accepted by Bunting and Jepson and Albert as a "primary endothelial sarcoma." Including this case, Jepson and Albert[35] have discovered the records of 31 cases, and they record a case under their own care. Of these 32 cases, 12 were treated by operation, 11 by splenectomy, and 1 by enucleation. The latter case, recorded by Heinricius, was one of pedunculated primary fibrosarcoma of the spleen, developing from the capsule of the gland. At the time of its enucleation it was thought to be a fibroma; but microscopic examination revealed a fibrosarcoma undergoing myxomatous degeneration. Of the 11 splenectomies, 3 died as a result of the operation, 8 recovered. Of these 8, 3 died of recurrence at times which are not certain, the result in 1 is unknown, the other 4 cases are living, $6\frac{1}{2}$ years, 4 years, 1 year, and a few months after the operation. As to the forms of sarcoma occurring in the spleen, Jepson and Albert write, "It is quite possible that future experience may show that it will be necessary to take further into consideration, when determining the amenability of the sarcomatous spleen to extirpation, the tissues from which the same arises. Thus the spleen offers three types of connective tissue from which it may originate. First, the capsule and trabecula; second, lymphoid structure; and third, the endothelial cells, which give rise respectively to the fibrosarcomata, lymphosarcomata, and endothelial sarcoma.

Symptoms and Diagnosis.—There is nothing characteristic in the symptoms or in the blood changes in cases of sarcoma of the spleen. The one clinical feature presented is an abdominal tumor. The tumor has usually been recognized as having its origin in the spleen, partly because it descends from beneath the left costal arch, partly because its surface presents the notches which are characteristic. The surface of the growth is almost always irregular, and the tumor feels solid and heavy. The discovery of nodules on the surface of the spleen is held by Litten to be a diagnostic aid of the first importance.

As a rule the tumor is painful and tender; the pain in a few of the recorded cases has been agonizing, preventing any slightest movement;

in these cases there may be the "creaking" on the surface of the growth, which is characteristic of perisplenitis. The only feature in any degree distinctive is, however, the rapidity of increase in the size of the tumor.

Secondary sarcoma is commoner than primary. Indeed it is not unlikely that some of the cases classed as primary are in truth secondary; the primary nodule being inconspicuous. There is no clinical interest in this condition. Carcinoma of the spleen has never been recorded in any case which will bear investigation.

Other Enlargements of the Spleen.—There are a variety of conditions, the pathology of which is in need of elucidation, in which an enlargement of the spleen is present. Such enlargement may be considerable, and at times surgical treatment may be necessary.

There is a **"simple hypertrophy"** of the spleen, the origin of which is entirely unknown. The closest clinical and pathologic investigation has so far thrown no light upon the condition, which is unattended by any marked or constant changes in the blood. The gross increase in the size of the organ may be attended by serious discomfort, or acute danger when the pedicle is twisted. Laspeyres (*loc. cit.*) in his summary of the recorded cases of splenectomy finds that in all, 16 operations have been performed for simple hypertrophy of the spleen with 3 deaths. The reasons which have led to the performance of the operation have been inconvenience caused by the heavy mass in the abdomen, acute rotation of the pedicle, and a belief that the tumor was malignant.

Malaria is accompanied by an enlargement of the spleen, which forms the so-called "ague-cake". Removal of this tumor has been not infrequently performed; at one time in the belief, now abandoned, that a good effect on the general course of the disease was thereby produced, latterly in several instances because the spleen had become displaced or its pedicle rotated. The malarial spleen should never be removed simply because of its enlargement, but if it becomes unduly mobile, or suffers rotation of the pedicle or rupture, it must be removed. Bessel Hagen reported 64 cases with 15 deaths, Laspeyres 69 cases with 6 deaths.

Banti's Disease.—*Splenic anemia.*—Splenic anemia is a chronic disease, beginning as a rule in young adults, and having a clinical course extending over several years. It is characterized according to Rolleston by—(1) Splenic enlargement which cannot be correlated with any known cause; (2) absence of enlargement of the lymphatic glands; (3) anemia of a type midway between secondary anemia and chlorosis; (4) leukopenia, or at most, no increase in the number of the white blood corpuscles; (5) an extremely prolonged course, lasting years; (6) a tendency to periodic hemorrhages, especially from the gastro-intestinal tract.

In addition to these it may be mentioned that a pigmentation of the skin is not seldom present, and that there is a tendency for the disease to occur in members of the same family. The changes in the blood are a diminution of the red blood-cells, to an average of 3,500,000 per cmm., and a reduction in the hemoglobin value of the red cells.

The leucocyte count is generally reduced; this is a most characteristic feature, but it may be altered as a result of the hemorrhages which may occur, and when occurring are often considerable. Banti[36] described a series of cases where splenic anemia became complicated in its later stages with cirrhosis of the liver, jaundice, and ascites; in the gradual evolution of this disease he described three stages; in the first, anemia and splenic enlargement are found, the former being secondary to the latter; in the second stage cirrhosis of the liver commences, there is a persistent diminution in the quantity of the urine, and an increase in the bile pigment and the urates; in the third stage there is ascites, insidious in origin, and painless. The course of the disease though generally slow may be rapid. The progress of the case is steadily downward; after the onset of cirrhosis the health of the patient often fails rapidly. Death may come either as the result of a series of very severe hemorrhages or from gradual exhaustion. The exact relationship between Banti's disease and other forms of splenomegalic cirrhosis (*e. g.*, hypertrophic biliary cirrhosis) is not quite clear. It is, however, probable that in splenic anemia it is the spleen which, having undergone a great increase in size, as the result of the irritation of toxins derived probably from the intestine, engenders those poisons which in a later stage of the disease set up cirrhosis of the liver. Rolleston, in the article to which reference has been made, reminds us that the idea of hepatic cirrhosis being secondary to poisons formed in the spleen has been insisted upon by Chauffard, who in this connection regards the portal vein as formed of two branches—the intestinal and the splenic—either of which may convey to the liver poisons capable of inducing cirrhosis. The removal of the spleen in an early stage of the disease would accordingly seem to be the rational treatment. There is now abundant evidence to show that if splenectomy is performed the course of the disease is arrested. Jaundice, ascites, and cirrhosis of the liver it would appear are then, later, preventible manifestations.

The circumstances under which surgical advice is likely to be sought are two: first, when the splenic tumor is of moderate or large size, perhaps of a size to cause inconvenience or danger, and second, when hemorrhage, epistaxis, hematemesis or melaena has occurred. In 1 case I was asked to see a patient, a man of thirty-four, with a view to an operation for hemorrhage from a supposed duodenal ulcer.

If splenectomy is to be of any value in arresting the disease, it is necessary that it should be performed before unalterable changes have occurred in the liver or other parts Senator has expressed the belief that when the removal of the spleen has proved successful it is because the operation was performed before the bone-marrow had become involved.

In a few cases, however, operation has been successfully undertaken at a late stage, after the development of ascites. Tansini, in such circumstances, performed splenectomy and epiplopexy; four weeks later the abdomen had to be tapped, but the patient recovered and remained well up to the time of the report several months later.

A similar case is related by Rafferty.

It is impossible to give any accurate information of the results either immediate or remote which have attended the operation of splenectomy for splenic anemia. For there can be no doubt that a number of cases of mere hypertrophy of the spleen are described as cases of Banti's disease in an early stage, and that cases of cirrhosis of the liver attended by enlargement of the spleen and hemorrhage from dilated gastric veins have been mistaken for cases of an advanced type.

It is clear, however, that in properly selected cases the operation of splenectomy holds out a prospect of cure to these patients whose end is otherwise certain, and that the immediate risks of the operation are slight.

WOUNDS AND INJURIES OF THE SPLEEN.

Injuries of the spleen are of three kinds:

1. Prolapse of the spleen;
2. Penetrating wounds;
3. Subcutaneous rupture.

1. **Prolapse of the Spleen.**—This occurs when the spleen escapes, wounded or uninjured, through a rent in the abdominal wall. The injury is rare, only 3 cases, according to Laspeyres,[15] having occurred in the eight years preceding 1904. The extrusion of the organ takes place, it is said, when a wound is made in the upper abdominal wall, or through the wall of the chest on the left side low down, and when in the acme of his sudden agony the patient straining heavily, compresses the chest and the abdominal wall to their utmost. It is probable that in all cases the pedicle of the spleen is longer than normal.

The whole gland or only a portion of it may present through the wound; if the whole gland, the pedicle is compressed, and a considerable engorgement is the result. In 1 such case Ledderhose observed the organ became gangrenous.

The treatment of this condition will depend upon the state of the spleen; if unwounded, it may be cleansed and returned within the abdomen; if torn or seriously damaged by bruising or exposure it should be removed. If an attempt is to be made to replace the organ, a careful inspection of all its surfaces and of the vessels in the pedicle is necessary to discover any injury to them. Death has occurred as a result of bleeding from a hidden laceration. Reposition has been followed by peritonitis, local and general, and by suppuration within and external to the gland. On the whole, therefore, splenectomy is the operation to be chosen.

2. **Penetrating wounds** are due either to gunshot or to stab wounds.

Schafer[37] has collected and analyzed the reports of 88 cases of penetrating wounds of the spleen; of these, 71 were due to gunshot and 17 to stab wounds.

In the 71 cases of gunshot wounds, there was only a single case in

which the spleen alone suffered injury, and in this instance it was considerably enlarged as a result of malaria. The frequency with which the other viscera were injured is shown in the following list:

The diaphragm	56
Left pleura	50
Stomach	32
Liver	28
Left lung	23
Left kidney	11
Pericardium	8
Heart	4
Small intestine	3
Large intestine	3
Pancreas	3
Spinal cord	3
Right pleura	2
Right kidney	2
Left adrenal	1
Aorta	1

Among the 17 cases of stab wounds the pleura, diaphragm, and spleen were simultaneously injured in 14 cases; in 2 of these 14 the left lung and the left kidney were also wounded, and in 1 the transverse colon. In 2 the spleen alone was damaged, and in the remaining case the injuries were multiple.

Injuries of this kind are almost invariably fatal, and speedily so, from hemorrhage. They should be treated, therefore, by instant operation. Schafer records 11 cases in which the splenic wound was closed by suture, and in 9 recovery followed. Splenectomy was performed in 10 cases, only 3 patients recovering. To these, Laspeyres adds 8 cases of splenectomy, 5 for gunshot wound, 3 dying, 2 recovering; and 3 for stab wounds, 2 dying and 1 recovering. In a total of 18 cases of splenectomy there were 12 deaths and 6 recoveries. The inference from these records is, therefore, that suture of the wounded organ should be performed when possible, and that splenectomy should be reserved for the injuries too extensive for suture.

3. **Subcutaneous Rupture.**—In cases of subcutaneous rupture of the spleen the gland is found, as a rule, greatly damaged. It may be torn into two or more pieces, some of which lie free in the peritoneum; wrenched away from its hilum; reduced to a pulp; or crushed within its unruptured capsule. Blood may escape in enormous quantities and with terrifying rapidity, causing speedy death; or the blood may become encapsuled, and later give rise to a cyst; or it may become encapsuled apart from the organ and remain latent, or finally the hematoma may undergo suppuration.

Lewerenz[38] has collected the records of 135 cases of subcutaneous rupture of the spleen recorded up to the year 1900. Among these were 82 cases in which the organ showed gross pathologic changes, such as malarial enlargement; in 9 cases the enlarged spleen of late pregnancy was injured.

In 104 cases the result was fatal, and in almost all death occurred within twenty-four hours. In 5 cases death was delayed for periods

varying between two and six weeks and was caused by secondary inflammatory processes occurring in the effused blood. Splenectomy was performed in 25 cases, with 13 recoveries; tamponade in 2 cases; 1 recovering; suture in 1 case, which died. Laspeyres[39] has found in the statistics of the eight years preceding 1904, 58 cases of splenectomy for subcutaneous rupture, of these 39 recovered—67.2 per cent.

Injuries of other organs are observed in a small proportion of cases: rupture of one or both kidneys, laceration of the left lobe of the liver, wound of the lung with hemothorax and hemopericardium, and in one case fracture of the pelvis with rupture of the urethra have been recorded.

Rupture of the spleen is almost always traumatic in origin. Cases are recorded, however, in which a spleen when greatly increased in size, as a result of malaria or typhoid or pregnancy, has torn with little or no apparent cause. Thus, Cimbali, quoted by Litten,[17] observed rupture of the spleen in a man of sixty-five who had enlargement of the gland, the result of malaria. One morning as the patient was getting out of bed he suddenly felt a severe pain in his left side and soon turned pale and cyanotic and died. A tear 3 to 4 cm. in length was found in the upper end of an enormously enlarged spleen.

Symptoms of Rupture of the Spleen.—The symptoms of rupture of the spleen do not differ appreciably from those of other severe injuries to the abdomen and its contents; in the very great majority of cases no accurate diagnosis has been made before operation, or before the death of the patient. Berger[40] has called attention to the fact that 51.8 per cent. of all cases of splenic rupture prove fatal within the first hour from hemorrhage.

The blow which causes the injury to the spleen is generally received upon the middle or upon the left side of the abdomen, though there are accurately observed cases in which the patient in falling has struck only the right side. After the receipt of the injury the patient may seem but little hurt, he may walk home after a brief rest. In Ballance's first case the patient was struck "in the stomach" by a cricket-ball. "After resting a few minutes he walked home, the distance being about fifteen minutes' walk. He had his tea at eight o'clock, as soon as he reached home, and then at once went to bed." Pain is felt, generally very acutely at the time of the injury, and as a rule continues without intermission. The patient may be sick, faint, and collapsed, and he soon shows the signs of an acute anemia. It is clear in most of the recorded cases that "internal hemorrhage" was recognized, though the origin of the blood may not have been suspected. The pulse is thin, rapid, feeble; the respirations are frequent and shallow, the face is pale and clammy, the extremities cold. The abdomen on examination is invariably rigid and still, the muscles tense, protecting, by a muscular bastion, the injured viscus. The rigidity of the abdomen is universal, but it may be more pronounced in the upper left quadrant than elsewhere. As a rule, it is evident that there is free fluid in the peritoneal cavity, and on percussion there is a fixed dulness in the splenic region. This is due, as we learn, from the conditions disclosed when the abdomen

is opened, to the presence of large clots of blood in all the area around the damaged organ. Ballance has called attention to a sign of great significance in these cases. He points out that though both flanks are dull on percussion, owing to the presence of blood free in the peritoneal cavity, the right flank alone becomes entirely resonant on change of position. When the patient turns over to the right the fluid blood slowly drains to the lower side, but the clots which are found on all occasions are fixed and continue to reveal a dull note on percussion. When the patient is turned to lie on his left side the right becomes completely empty and, therefore, resonant. This sign, "Ballance's sign," gives the one clue to an accurate diagnosis. If present, it is pathognomic of splenic rupture; if absent, however, it may still be the spleen that is injured. This is one of the very few occasions upon which percussion of the abdomen affords help in diagnosis.

Treatment.—The following methods of treatment may be adopted: splenectomy; suture of the wound; crushing of the margins of the wound by large forceps, followed by suture; tamponade; cauterization.

In the majority of instances the removal of the organ is the safest procedure. The spleen when freed from the blood by which it is inundated is found so damaged that any attempt to save it is clearly impossible. At the moment when it is exposed, the most furious bleeding may occur from it, and the patient's life may be in great peril. It is best then to apply a clamp to the splenic vessels to control the hemorrhage until a careful inspection of the organ can be made. When the injuries are multiple, or the rent large or irregular, splenectomy should be done at once.

In some cases suture of the splenic wound has proved quite satisfactory; it has generally been combined with gauze packing and drainage. If closure of the wound is decided upon it is important to make sure that there are no other wounds present. Lamarchia has recorded 1 case in which after the suture of a tear on the inner surface death occurred from hemorrhage from an unnoticed wound on the posterior border.

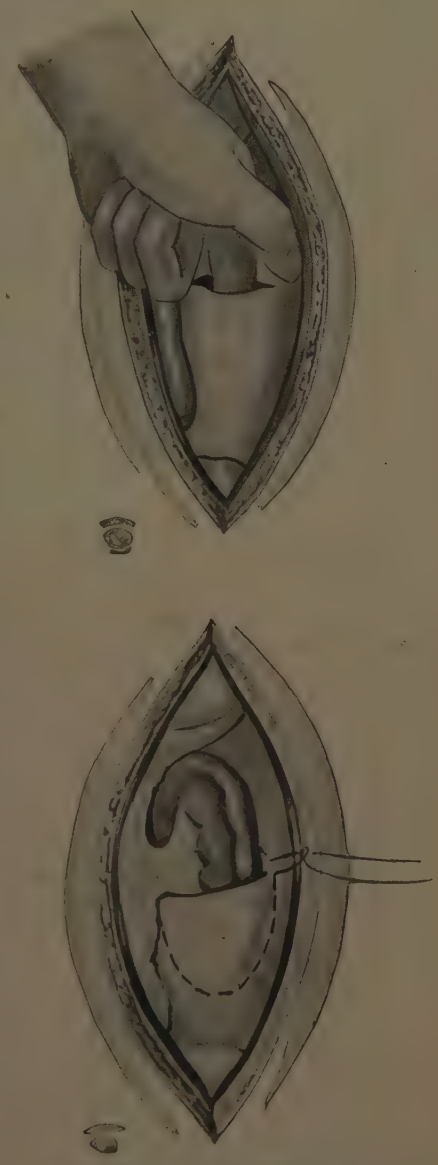
Nicholas Senn[41] in discussing traumatic hemorrhage from the spleen suggests that crushing the margins of the wound in the spleen should be adopted. Experimentally, he found that marginal crushing always completely arrested the hemorrhage from splenic wounds. Large forcipressure clamps were applied to each side of the wound; bleeding stopped at once; and the opposite surfaces were brought together by a few catgut stitches. He deprecates the ready resource to splenectomy which is prevalent, and points out that the compensatory mechanism after splenectomy may not always be satisfactory; and recalls the fact that regeneration of splenic tissue has been experimentally proved.

Partial splenectomy and gauze packing of wounds are both measures that may occasionally be used when the methods previously mentioned are inapplicable.

OPERATIONS UPON THE SPLEEN.

Splenectomy.—The removal of the spleen may be an easy or an extremely difficult operation; easy when the gland is readily accessible, provided with a long pedicle, and free from adhesions; difficult when the patient is stout, the spleen small or fixed by adhesions, and the pedicle is short. Operators of conspicuous ability and dexterity have had to abandon efforts at removal of the organ.

As a rule, when the spleen is large, a central incision is made, in other cases the abdomen is opened through the left linea semilunaris. As soon as the abdomen is opened the peritoneum is packed off with swabs and the spleen is exposed; adhesions are methodically and carefully divided and ligatured, and the organ is delivered through the wound. Care is taken that the thin-walled vessels of the pedicle do not suffer injury from tension. The splenic vessels pass to the spleen between the layers of the lienorenal ligament, which is clamped or transfixed, and subsequently ligatured. As a rule, two interlocking ligatures are best, but if the vessels are much enlarged a series of ligatures secures better control. In some cases the tail of the pancreas has been included in the ligature applied to the pedicle.



FIGS. 561 AND 562.—RYDYGIER'S OPERATION FOR SPLENOPEXY.

Splenectomy has been employed in cases of cyst of the spleen or in abscess. The operative details are similar to those in other operations upon internal organs. The gland may be approached through an abdominal incision or by the transpleural route.

Splenopexy.—Several methods have been suggested, of which the following are the chief:

Tuffier's Method.—Suture of the spleen to the diaphragm or abdominal wall. The stitches may be of silk or catgut, and pass into the substance of the organ. Tuffier does not mention whether any hemorrhage occurred from the spleen in his case. This operation has been performed by Greiffenhagen, who passed two stout silk sutures through the abdominal wall and through the parenchyma of the spleen. Alarming hemorrhage followed which was controlled with difficulty. This method is not one to be commended. The risk of hemorrhage is serious. Other and safer methods have now displaced it.

Kouwer's Method.—Kouwer, in both his cases, fixed the spleen by tamponade, thus causing the formation of a large number of adhesions. The consolidation of the adhesions secured the fixity of the spleen.

Rydygier's Method.—The abdomen is opened in the middle line or through the linea semilunaris. The diaphragm is exposed, and a transverse incision between the ninth and tenth ribs is made. The peritoneum above and below this incision is raised up by the finger until a pocket on each side is formed. To do this below is easy, but on the upper side the adhesion to the diaphragm is so close that the peritoneum tears away. A continuous suture (or a series of interrupted sutures) is now applied around the upper and lower margins of the pocket, so as to limit the cavity formed by the raising up of the peritoneum. The spleen is then placed in the pocket formed for it.

Bardenheuer's Method.—The patient lies on the right side, as for an operation upon the left kidney. A longitudinal incision is made in the axillary line, reaching from the tenth rib to the iliac crest. At the upper end of this a transverse incision is added to give additional room. The soft parts are divided down to the peritoneum, which is stripped up over an area rather larger than the area of the spleen. The peritoneum is then incised, the opening being made of as small a size as will allow the passage of the spleen through it. The spleen is sought and found and drawn through the opening in the peritoneum. The size of the opening is then lessened by a few points of suture, and the wound in the parietes closed. The spleen by this operation is brought to lie altogether outside the peritoneum.

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